

# FLASH Product Suite

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# Organization

- Total of 35 products in 6 categories
- Mixture of observations, hydrologic models, QPE, QPF, flash flood guidance, and precipitable water

FLASH	
-----Obs-----	
Flood Warnings and Advisories	30.1953
Local Storm Reports	30.1736
-----Models-----	
CREST Max Return Period	30.1945
HRRR-Forced CREST	30.1945
CREST Soil Moisture	30.1945
CREST Streamflow	30.1945
SAC-SMA Soil Moisture	06.2200
SAC-SMA Streamflow	30.1945
-----Precipitable Water-----	
Precipitable Water Analysis (RAOBs)	30.0000
Precipitable Water Percentile (RAOBs)	30.0000
Precipitable Water Analysis (RAP)	30.1900
Precipitable Water Percentile (RAP)	30.1900
-----QPE and QPF-----	
MRMS QPE	▶
HRRR QPF	▶
-----Flash Flood Guidance-----	
QPE to Flash Flood Guidance	▶
QPF to Flash Flood Guidance	▶
-----Precipitation Return Periods-----	
Precipitation Return Periods (QPE)	▶
Precipitation Return Periods (QPF)	▶

# “Observations”

- Multiple sources

FLASH	
-----Obs-----	
Flood Warnings and Advisories	30.1953
Local Storm Reports	30.1736

Flash Flood Warnings, Flood Warnings, and Flood Advisories

– LSRs restricted to the following:

flood:



flash flood:



heavy rain:



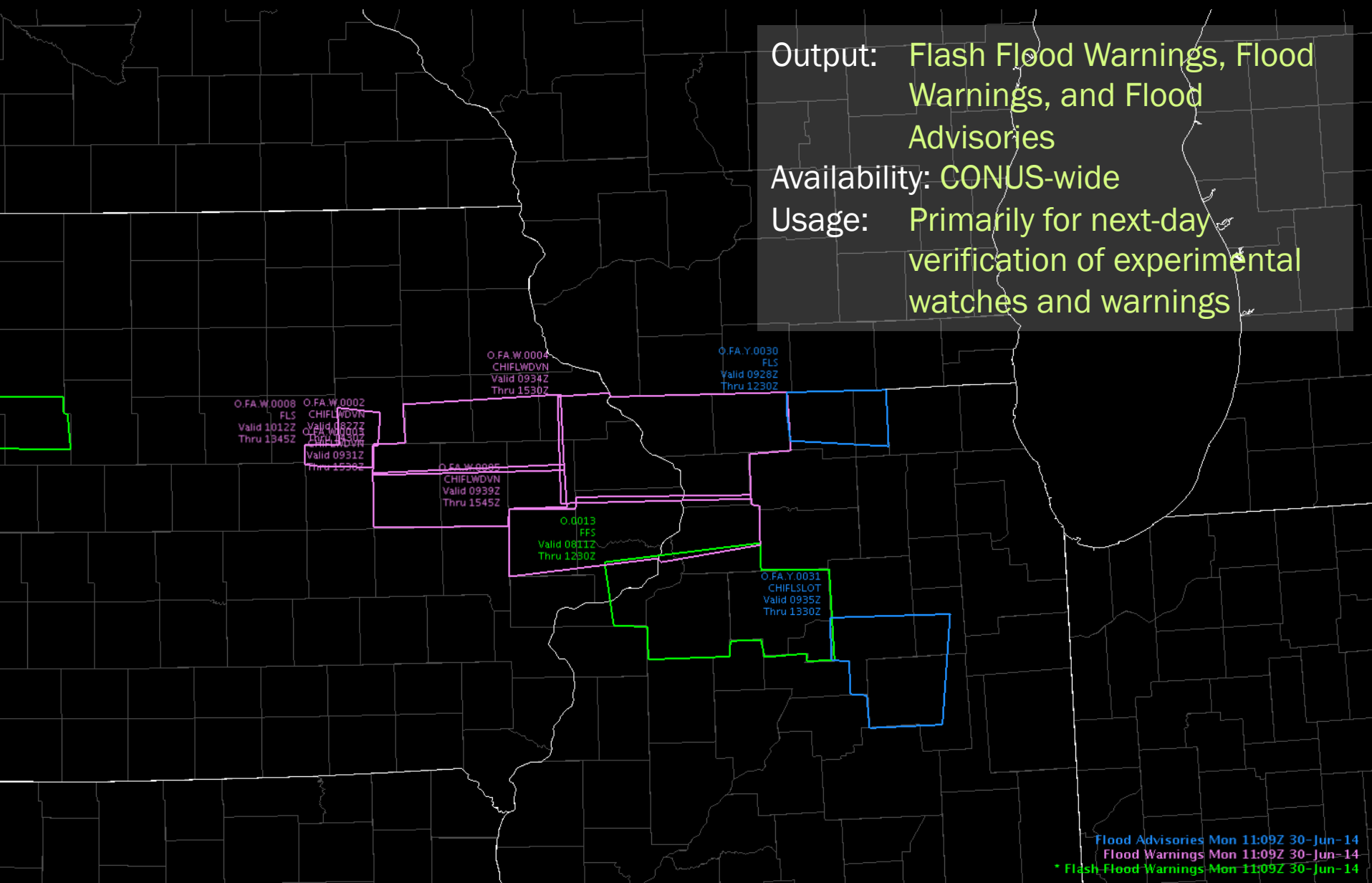
– CAVE will only show \*one\* LSR at a time

# Flood Warnings and Advisories

Output: Flash Flood Warnings, Flood Warnings, and Flood Advisories

Availability: CONUS-wide

Usage: Primarily for next-day verification of experimental watches and warnings



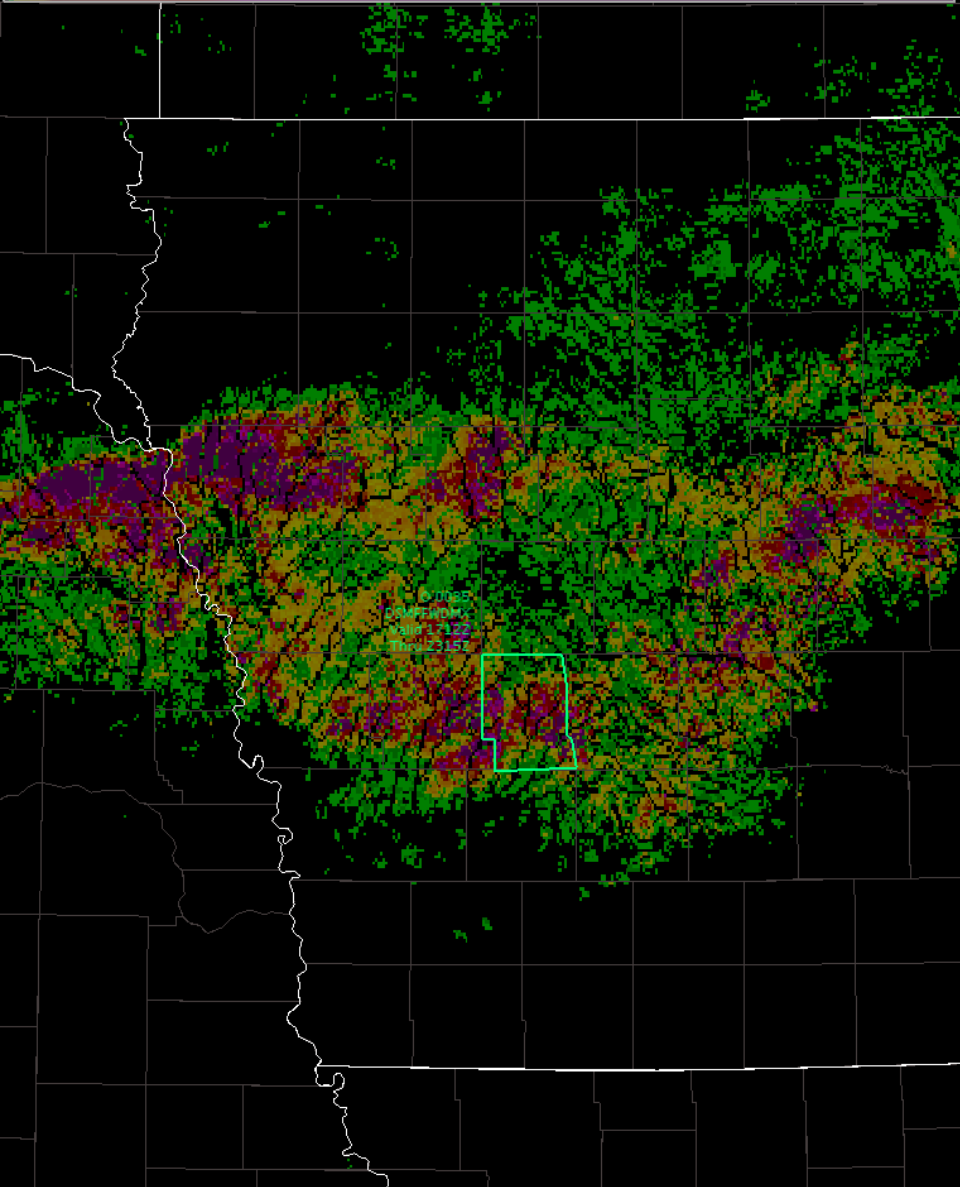
# Models

-----Models-----	
CREST Max Return Period	30.1945
HRRR-Forced CREST	30.1945
CREST Soil Moisture	30.1945
CREST Streamflow	30.1945
SAC-SMA Soil Moisture	06.2200
SAC-SMA Streamflow	30.1945

- 6 total products in the models category
- Includes two hydrologic models – CREST and SAC-SMA
- CREST – Coupled Routing and Excess Storage
  - Developed by OU and NASA
- SAC-SMA – Sacramento Soil Moisture Accounting model

# Models

- Will have access to two SAC-SMA products
  - Soil Moisture and Streamflow
- Four CREST products
  - Soil Moisture and Streamflow
  - Maximum Return Period
  - HRRR-forced Maximum Return Period
- All six available every 15 minutes at 1 km resolution (CONUS-wide)

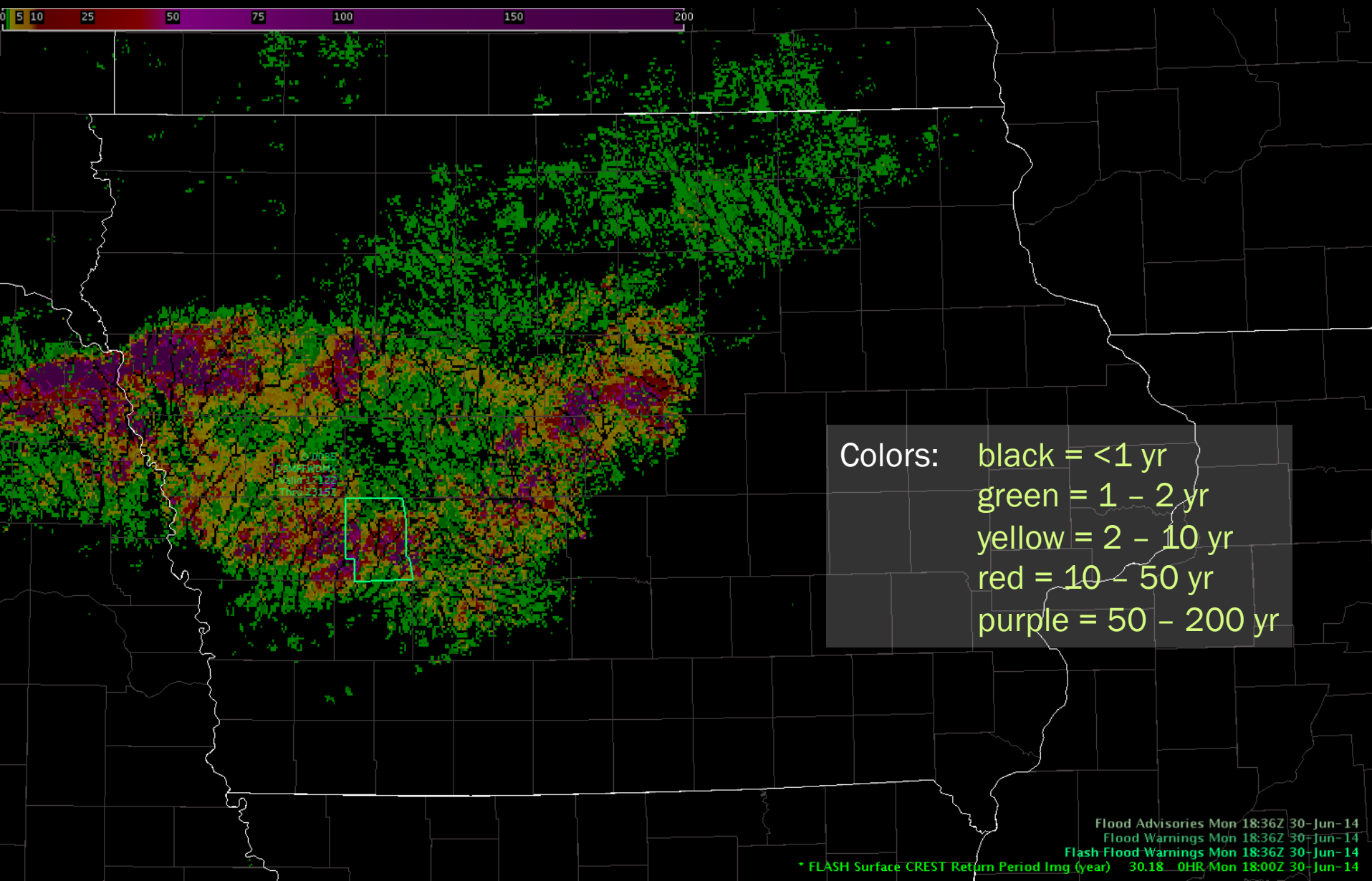


Input: MRMS radar-only QC'd precipitation rate

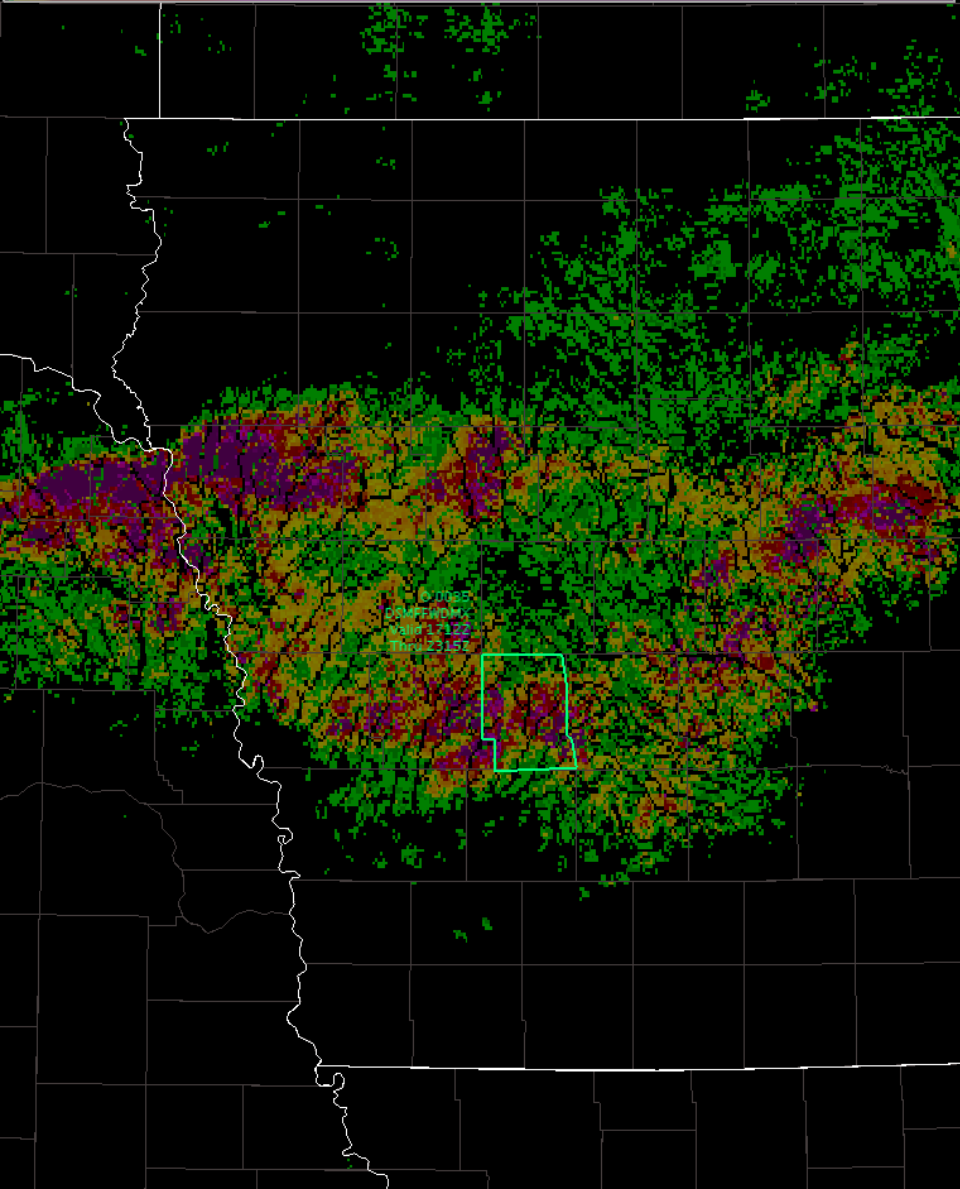
Usage: Look for contiguous areas of progressively higher values. Flooding is believed to begin at 2 yr (yellow) and up.

\* FLASH Surface CREST Return Period Imq (year) 30.18 0HR Mon 18:00Z 30-Jun-14

# CREST Max Return Period



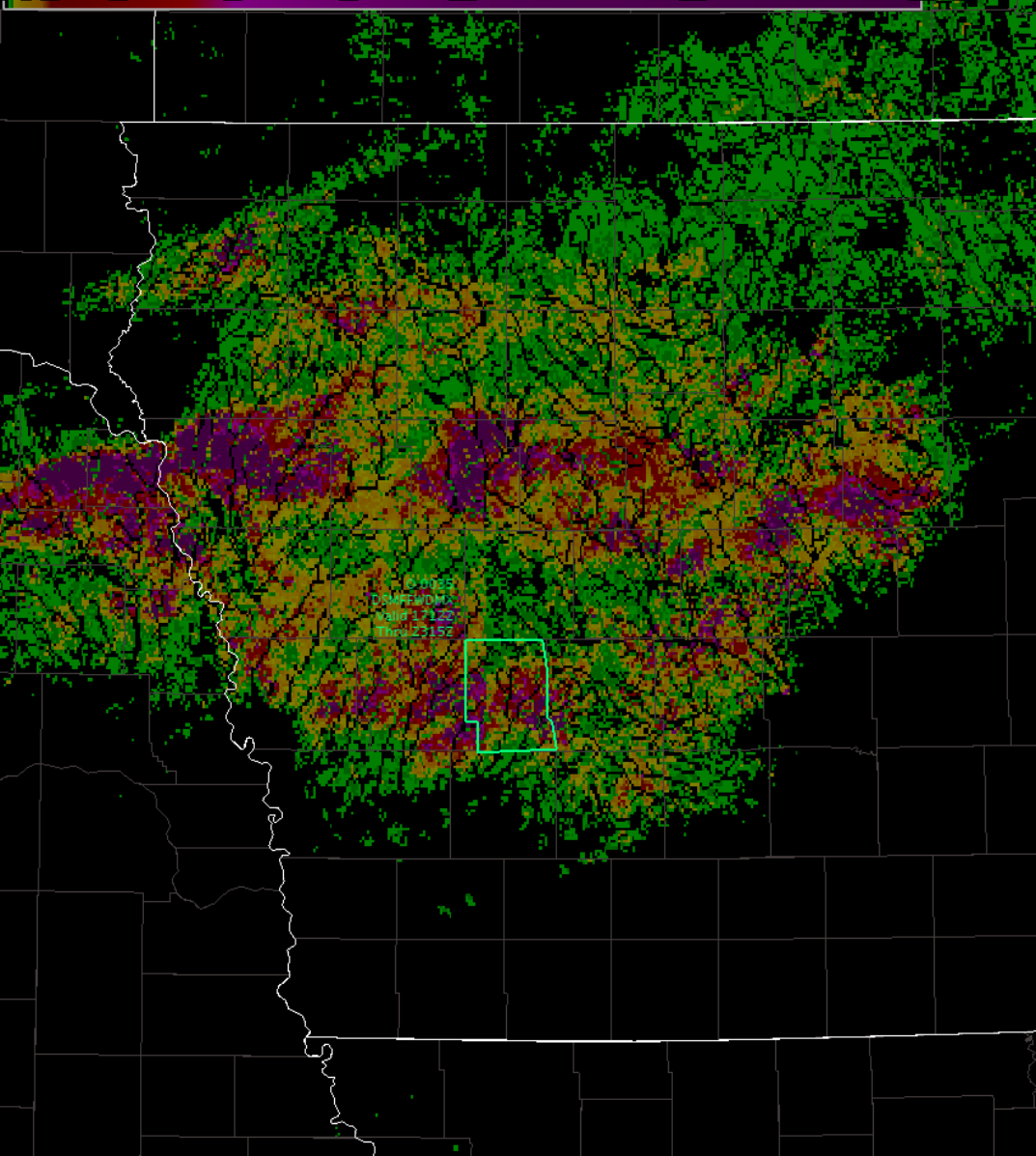




\* FLASH Surface CREST Return Period Imq (year) 30.18 0HR Mon 18:00Z 30-Jun-14

# HRRR-Forced CREST

0 5 10 25 50 75 100 150 200



**Output:** Return period  
Displays the maximum simulated return period between 30 min before and 6 hr after valid time

**Scale:** 0 - 200 yr

**Resolution:** 1 km x 1 km; 15 min

**Availability:** CONUS-wide excluding WA, ID, and OR. Should be in CAVE approx. 45 - 50 min after product valid time.

**Input:** MRMS radar-only QC'd precipitation rate and HRRR QPF

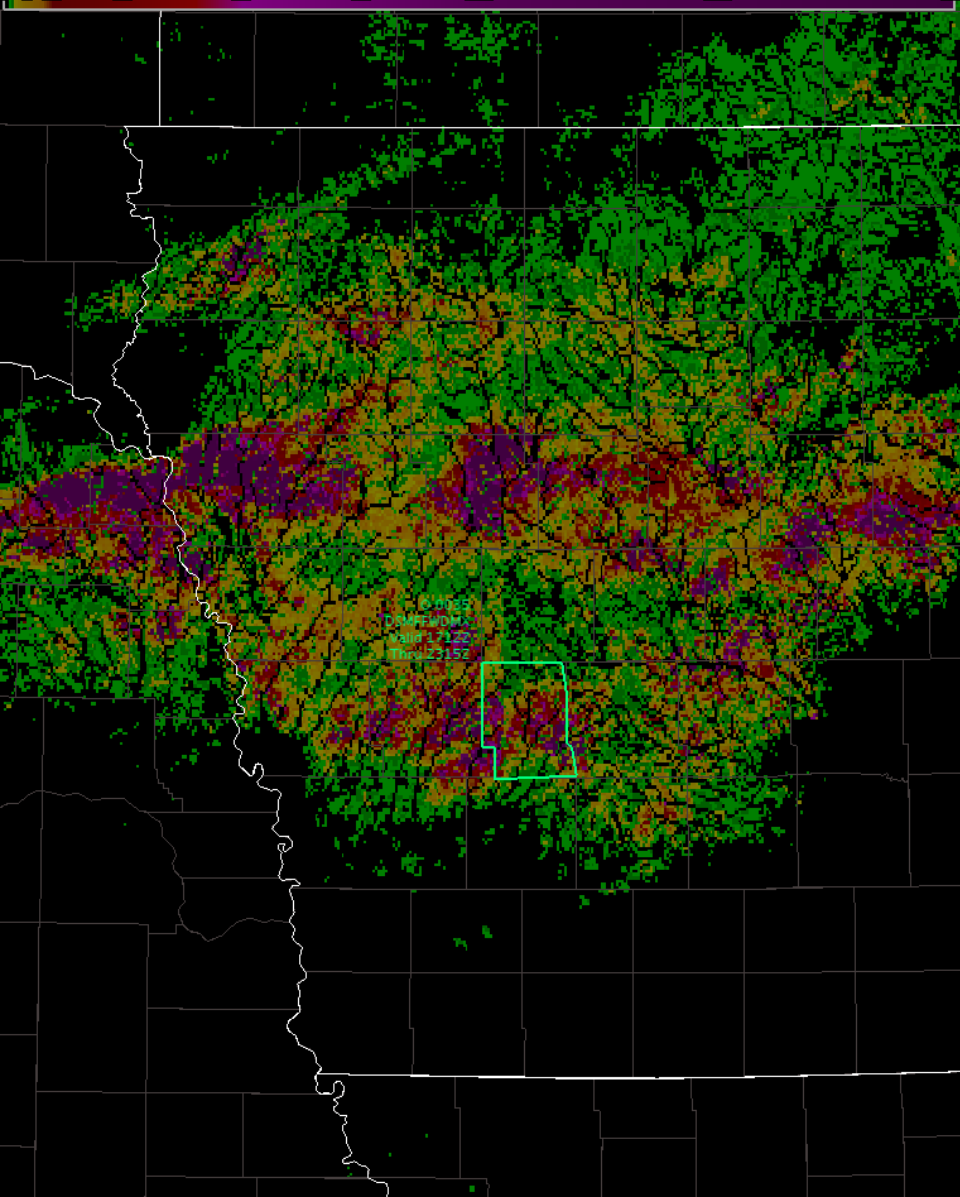
**Usage:** Look for contiguous areas of progressively higher values. Flooding is believed to begin at 2 yr (yellow) and up. Values will be higher than in QPE-forced CREST

Flash Flood Warnings Mon 18:36Z 30-Jun-14  
Flash Flood Warnings Mon 18:36Z 30-Jun-14

\* FLASH Surface HRRR-Forced CREST 1mg (year) 30.18 0HR Mon 18:00Z 30-Jun-14

# HRRR-Forced CREST

0 5 10 25 50 75 100 150 200



Technical Notes: This product works on the same principles at the “CREST Max Return Period” product (see product notes for more). Here, CREST receives QPF from the HRRR for hydrologic model hours 0 – 6 (in the QPE variation, rainfall in these hours is assumed to be zero). The HRRR QPF is from HRRR model hours 4 – 10. For example, a HRRR-Forced CREST grid valid at 4:00z will consist of MRMS precipitation prior to 4:00z and HRRR QPF from 4:00z to 10:00z (from the 00:00z HRRR model run). This product will, of course, always have higher values than the QPE variation, but the two products can still be compared when the valid times of each match in CAVE.

Flood Advisories Mon 18:36Z 30-Jun-14

Flood Warnings Mon 18:36Z 30-Jun-14

Flash Flood Warnings Mon 18:36Z 30-Jun-14

\* FLASH Surface HRRR-Forced CREST 1mg (year) 30.18 0HR Mon 18:00Z 30-Jun-14

# CREST Streamflow

0 200 400 600 800 1000

Output: Simulated surface water flows (max between 30 min before and 6 hr after the valid time)

Scale: 0 - 1,000  $\text{m}^3 \cdot \text{s}^{-1}$

Resolution: 1 km x 1 km; 15 min

Availability: CONUS-wide excluding WA, ID, and OR. Should be in CAVE approx. 45 - 50 min after product valid time.

# CREST Streamflow



**Input:** MRMS radar-only QC'ed precipitation rate

**Usage:** Use this for model diagnostics. Areas appearing in gray and light green are where rain is currently occurring/overland flows are being modeled. Channel flows tend to appear in purple and blue.

**Colors:**

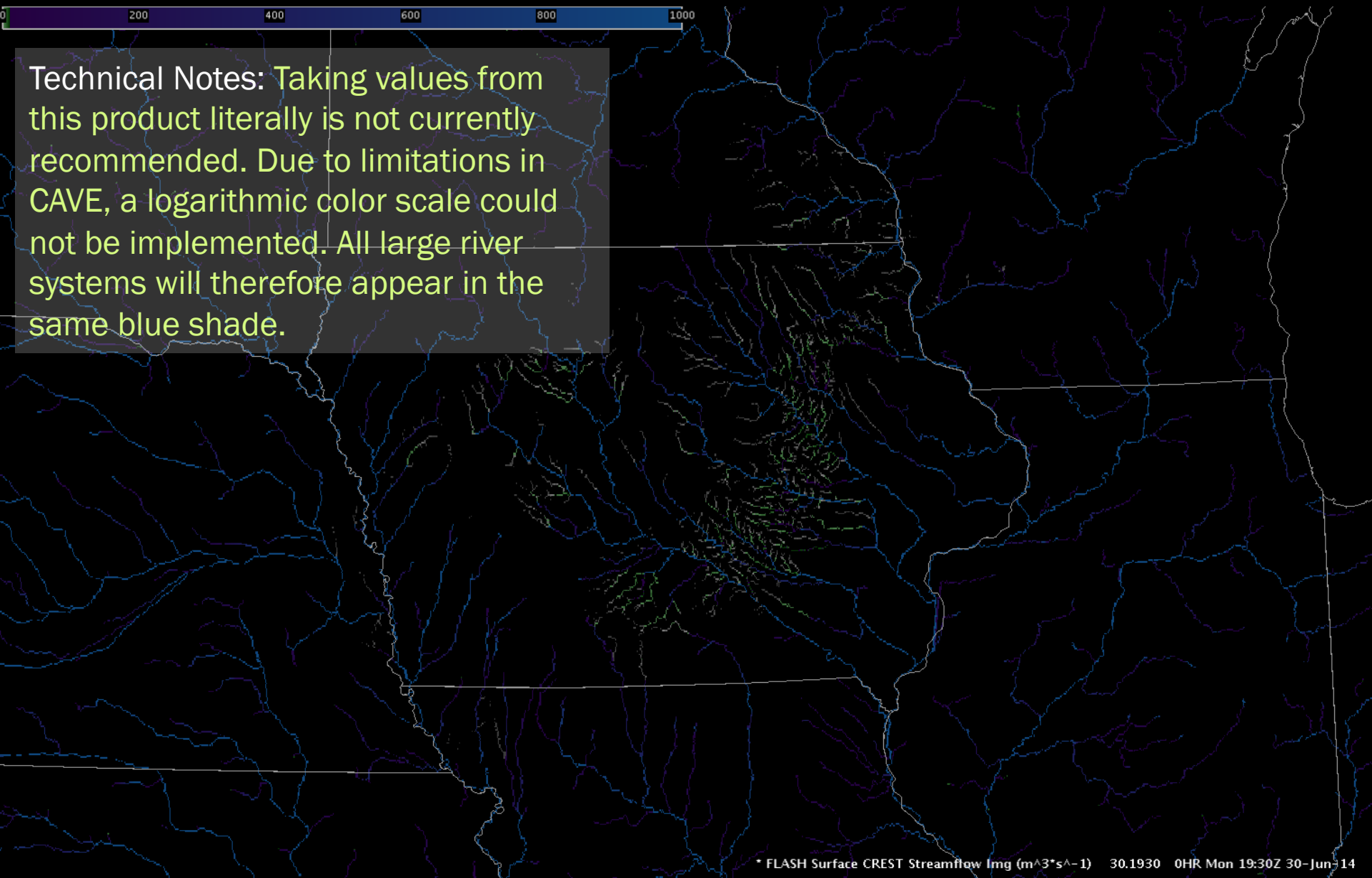
- black =  $0 \text{ m}^3 \cdot \text{s}^{-1}$
- gray =  $0.1 - 1.0 \text{ m}^3 \cdot \text{s}^{-1}$
- green =  $1 - 10 \text{ m}^3 \cdot \text{s}^{-1}$
- purple & blue =  $10 - 1,000 \text{ m}^3 \cdot \text{s}^{-1}$



# CREST Streamflow



Technical Notes: Taking values from this product literally is not currently recommended. Due to limitations in CAVE, a logarithmic color scale could not be implemented. All large river systems will therefore appear in the same blue shade.



# SAC-SMA Streamflow



Technical Notes: The basic information about this product is identical to its CREST counterpart. However, in general, values for this product are lower. Additionally, at close range, this product will look coarser because some parameter maps used in its development are 4 km x 4 km but the final resolution is still 1 km x 1 km. Taking values from this product literally is not currently recommended. Recent rainfall here will appear solid gray, not gray to light green.

# CREST Soil Moisture



Output: Soil moisture content

Scale: 0 - 100%

Resolution: 1 km x 1 km; 15 minutes

Availability: CONUS-wide. Should be in  
CAVE approx. 45 - 50 min  
after product valid time.

Input: MRMS radar-only QC'ed  
precipitation rate

Usage: Dark blue and dark green  
areas are nearly saturated.  
Gray areas are currently  
experiencing rainfall. It is  
likely that the same amount  
of rainfall in two areas will  
cause greater flooding  
impacts in the region with  
more saturated soils.



# SAC-SMA Soil Moisture

Output: Soil moisture content

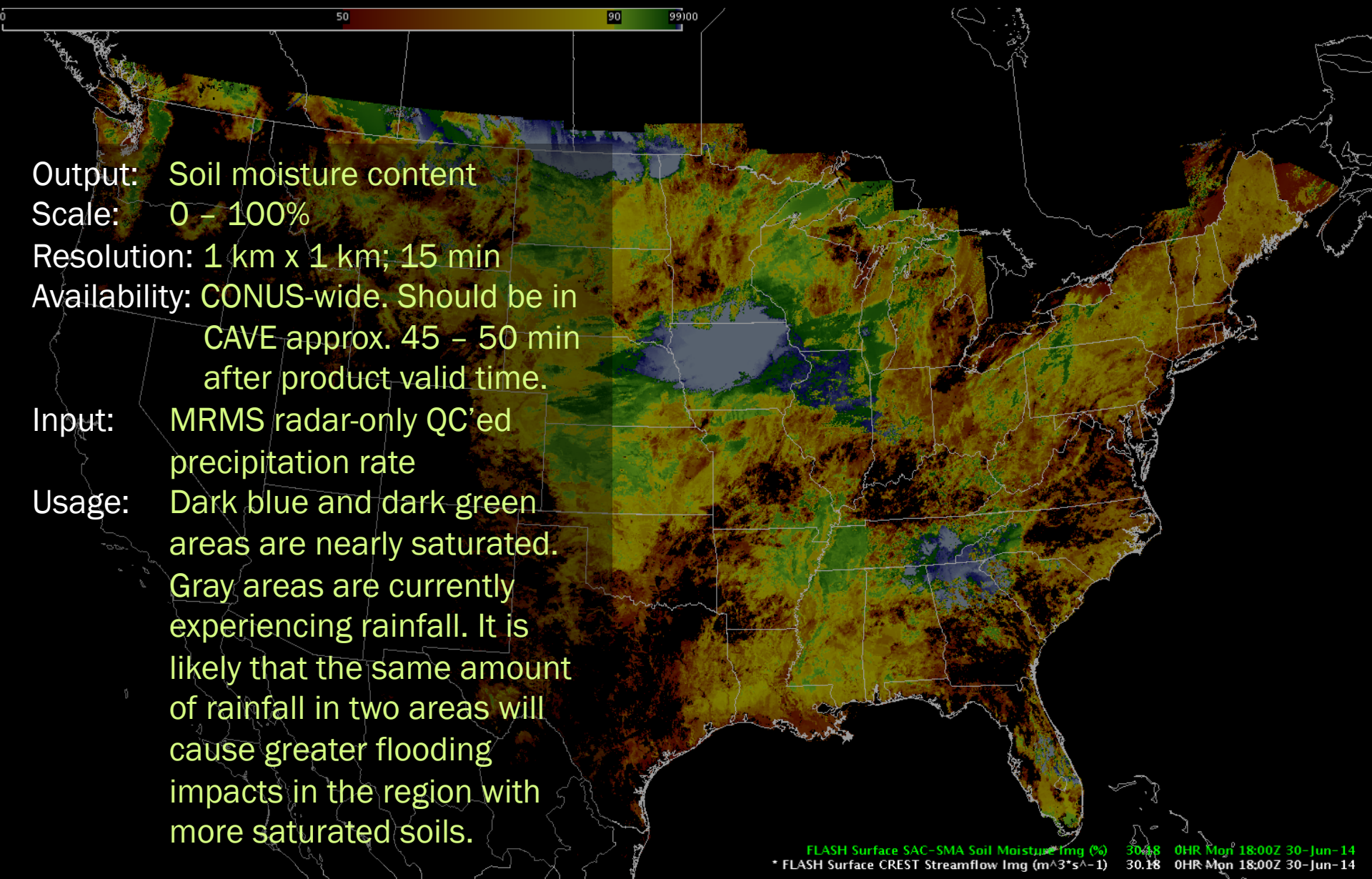
Scale: 0 – 100%

Resolution: 1 km x 1 km; 15 min

Availability: CONUS-wide. Should be in  
CAVE approx. 45 – 50 min  
after product valid time.

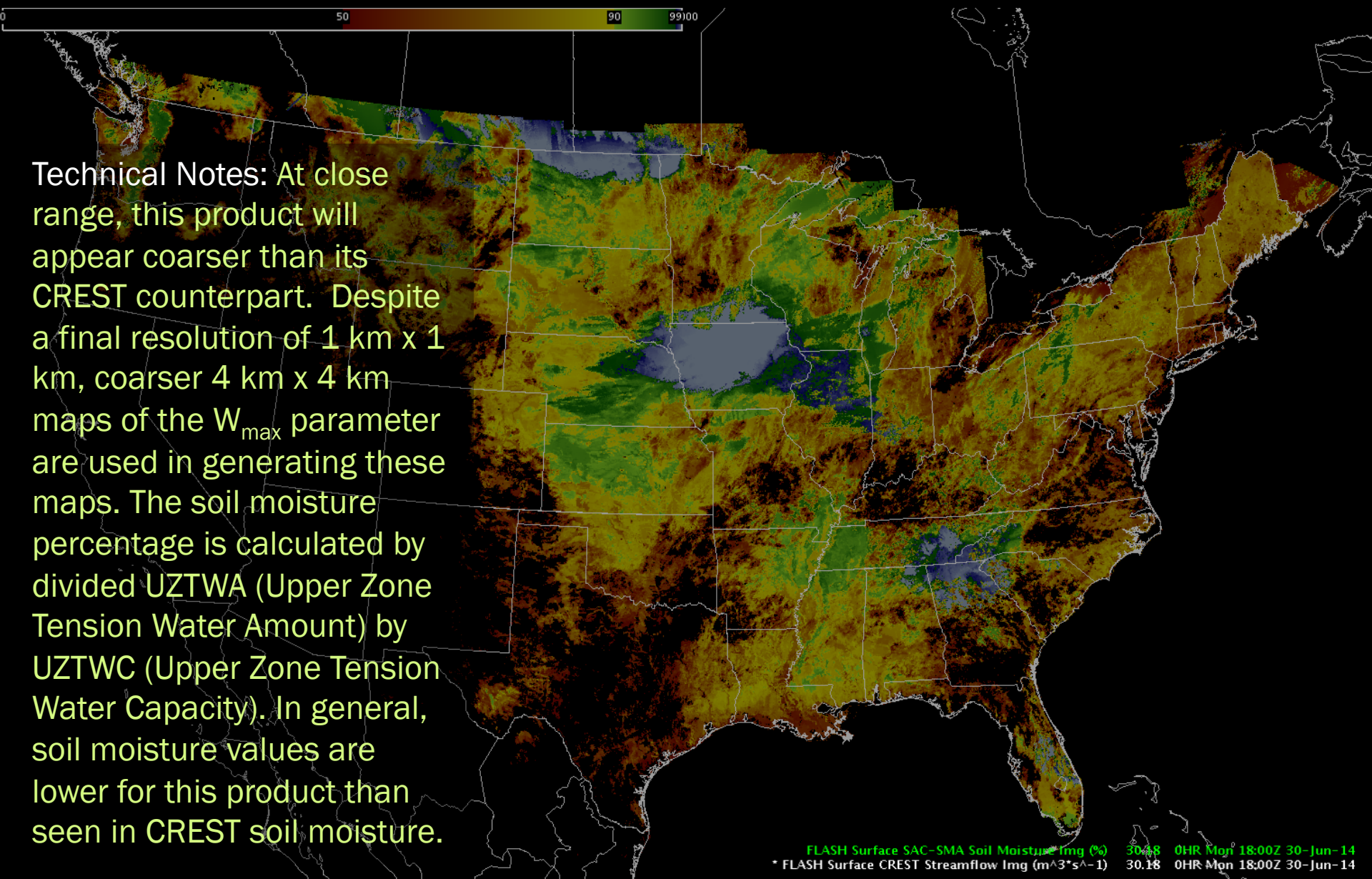
Input: MRMS radar-only QC'd  
precipitation rate

Usage: Dark blue and dark green  
areas are nearly saturated.  
Gray areas are currently  
experiencing rainfall. It is  
likely that the same amount  
of rainfall in two areas will  
cause greater flooding  
impacts in the region with  
more saturated soils.



# SAC-SMA Soil Moisture

Technical Notes: At close range, this product will appear coarser than its CREST counterpart. Despite a final resolution of 1 km x 1 km, coarser 4 km x 4 km maps of the  $W_{\max}$  parameter are used in generating these maps. The soil moisture percentage is calculated by divided UZTWA (Upper Zone Tension Water Amount) by UZTWC (Upper Zone Tension Water Capacity). In general, soil moisture values are lower for this product than seen in CREST soil moisture.



# Precipitable Water

- 4 total products
- Observations and model outputs
- Analysis and percentiles

-----Precipitable Water-----	
Precipitable Water Analysis (RAOBs)	30.0000
Precipitable Water Percentile (RAOBs)	30.0000
Precipitable Water Analysis (RAP)	30.1900
Precipitable Water Percentile (RAP)	30.1900



# Precipitable Water Analysis (RAOBs)



Output: Precipitable water (PWAT) (sfc  
– 300 mb)

Scale: 0.0 – 3.0 in

Resolution: 0.1 x 0.1 deg; 12 hr

Availability: Twice daily at 00 and 12z;  
should appear in CAVE by  
01 and 13z

Input: CONUS RAOBs

Usage: Higher PWAT values are  
associated with a greater  
probability of heavy rain and  
thus, flash flooding

# Precipitable Water Analysis (RAOBs)



Colors: black = 0 – 0.1 in  
blue = 0.1 – 0.75 in  
green = 0.75 – 1.5 in  
yellow = 1.5 – 2.0 in  
orange and red = 2.0 – 3.0 in

Technical Notes: PWAT values from 0 and 12z rawinsondes over the CONUS are objectively analyzed to the 0.1 deg MRMS grid via a Barnes analysis. Analyzed values are progressively less reliable the farther away from the CONUS you move.

# Precipitable Water Analysis (RAP)



Output: PWAT (sfc – 300 mb)

Scale: 0.0 – 3.0 in

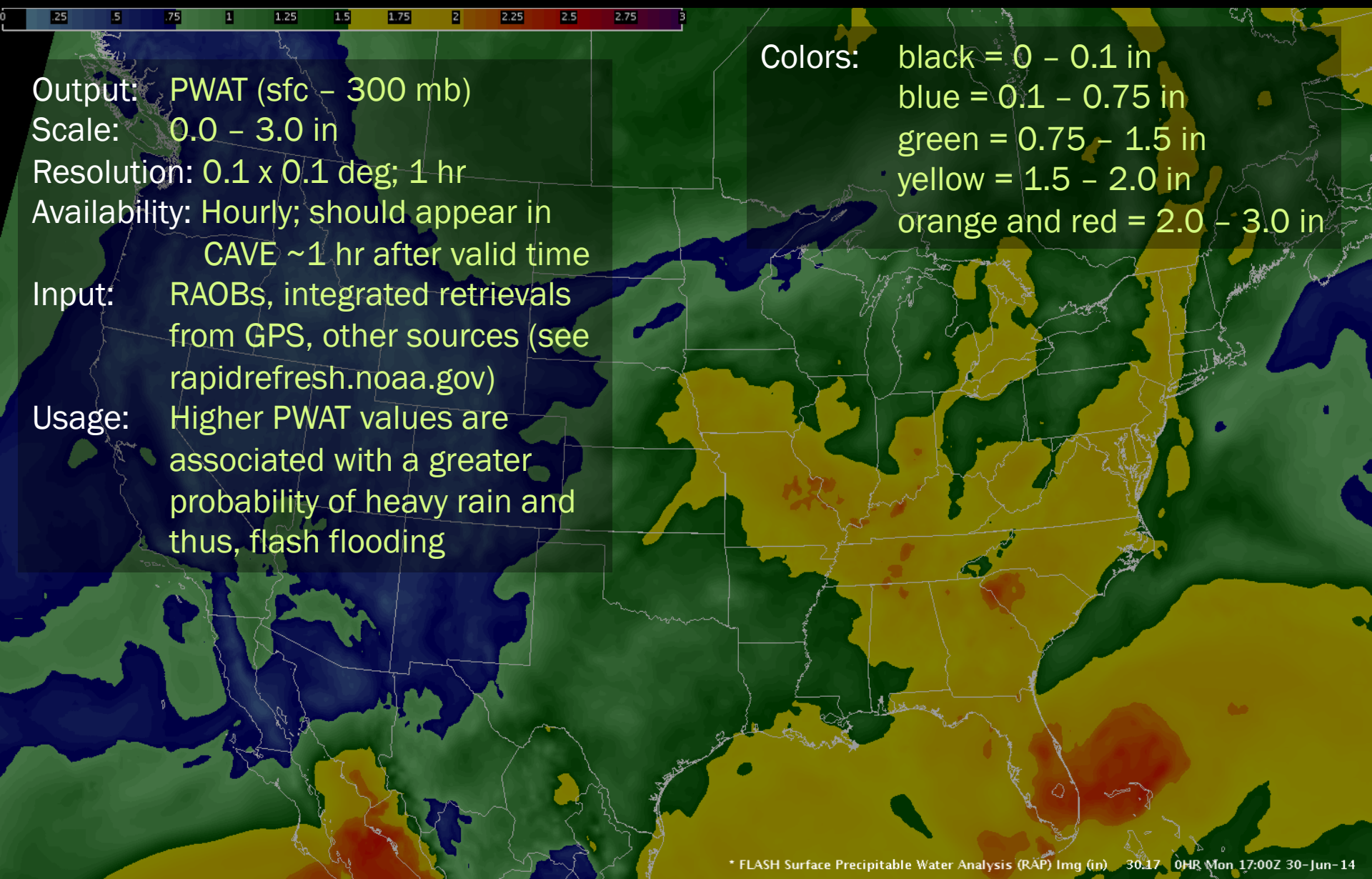
Resolution: 0.1 x 0.1 deg; 1 hr

Availability: Hourly; should appear in  
CAVE ~1 hr after valid time

Input: RAOBs, integrated retrievals  
from GPS, other sources (see  
[rapidrefresh.noaa.gov](http://rapidrefresh.noaa.gov))

Usage: Higher PWAT values are  
associated with a greater  
probability of heavy rain and  
thus, flash flooding

Colors: black = 0 – 0.1 in  
blue = 0.1 – 0.75 in  
green = 0.75 – 1.5 in  
yellow = 1.5 – 2.0 in  
orange and red = 2.0 – 3.0 in



# Precipitable Water Analysis (RAP)

Technical Notes: This product consists of the hourly PWAT analysis from NCEP's Rapid Refresh v2 weather model. It is resampled from its 13 km original resolution to the 0.1 deg MRMS grid but is otherwise unaltered from the original. The RAP v2 includes satellite retrievals, RAOBs, and other sources of information.





# Precipitable Water Percentile (RAOBs)

Output: PWAT (sfc – 300 mb)  
percentile

Scale: 0 – 100%

Resolution: 0.1 x 0.1 deg; 12 hr

Availability: Twice daily at 00 and 12z;  
should appear in CAVE by  
01 and 13z

Input: CONUS RAOBs, PWAT  
climatology

Usage: Values in the 90<sup>th</sup> percentile  
or higher suggest heavy  
rainfall is possible. Values in  
the 99<sup>th</sup> percentile have been  
associated with major flash  
flooding events.

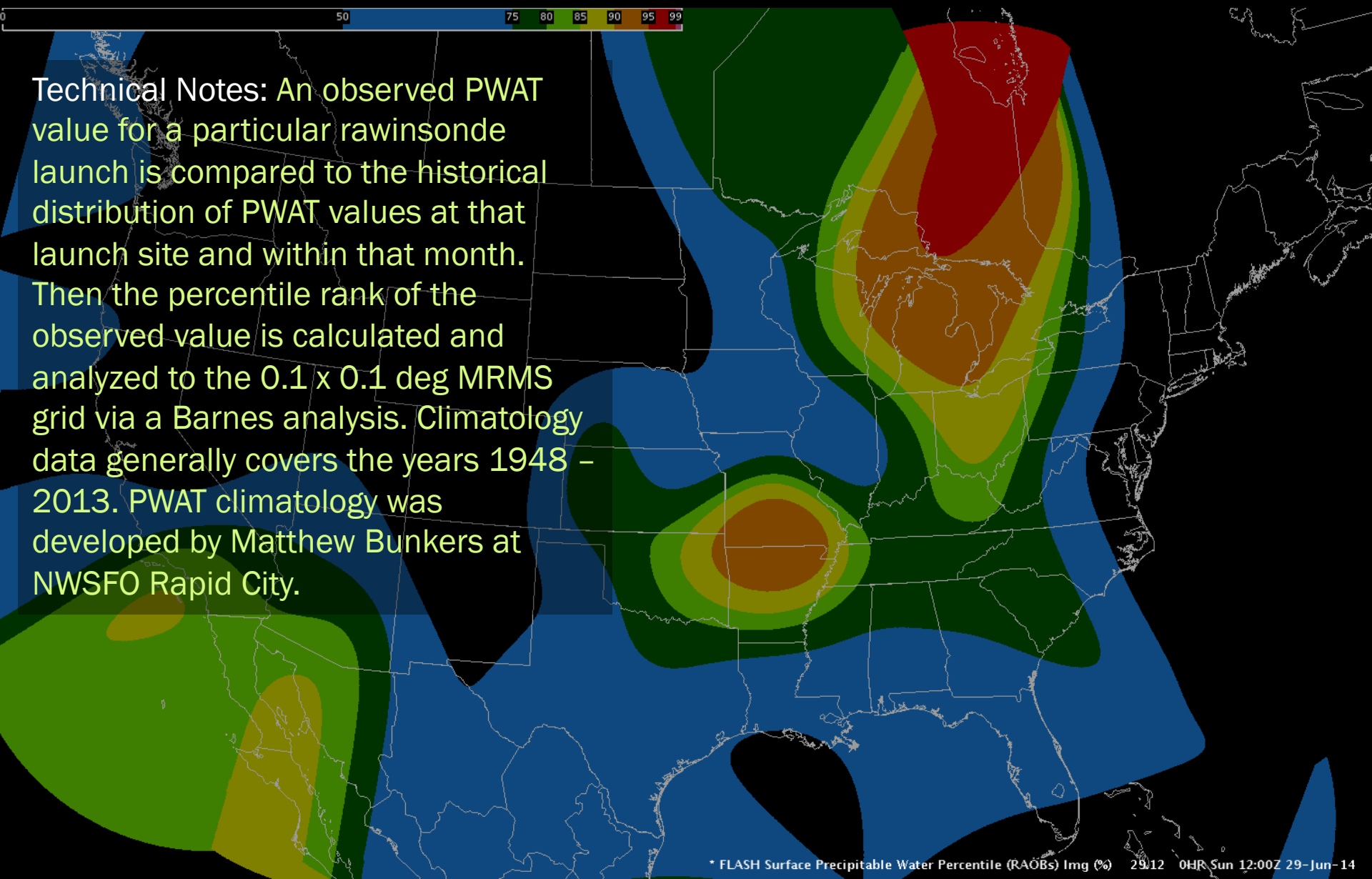
Colors:

black	= 0 – 50%
blue	= 50 – 75%
green	= 75 – 80%
yellow	= 85 – 90%
orange	= 90 – 95%
red	= 95 – 99%
pink	= 99 – 100%



# Precipitable Water Percentile (RAOBs)

Technical Notes: An observed PWAT value for a particular rawinsonde launch is compared to the historical distribution of PWAT values at that launch site and within that month. Then the percentile rank of the observed value is calculated and analyzed to the 0.1 x 0.1 deg MRMS grid via a Barnes analysis. Climatology data generally covers the years 1948 - 2013. PWAT climatology was developed by Matthew Bunkers at NWSFO Rapid City.



# Precipitable Water Percentile (RAP)

Output: PWAT (sfc – 300 mb)  
percentile

Scale: 0 – 100%

Resolution: 0.1 x 0.1 deg; 1 hr

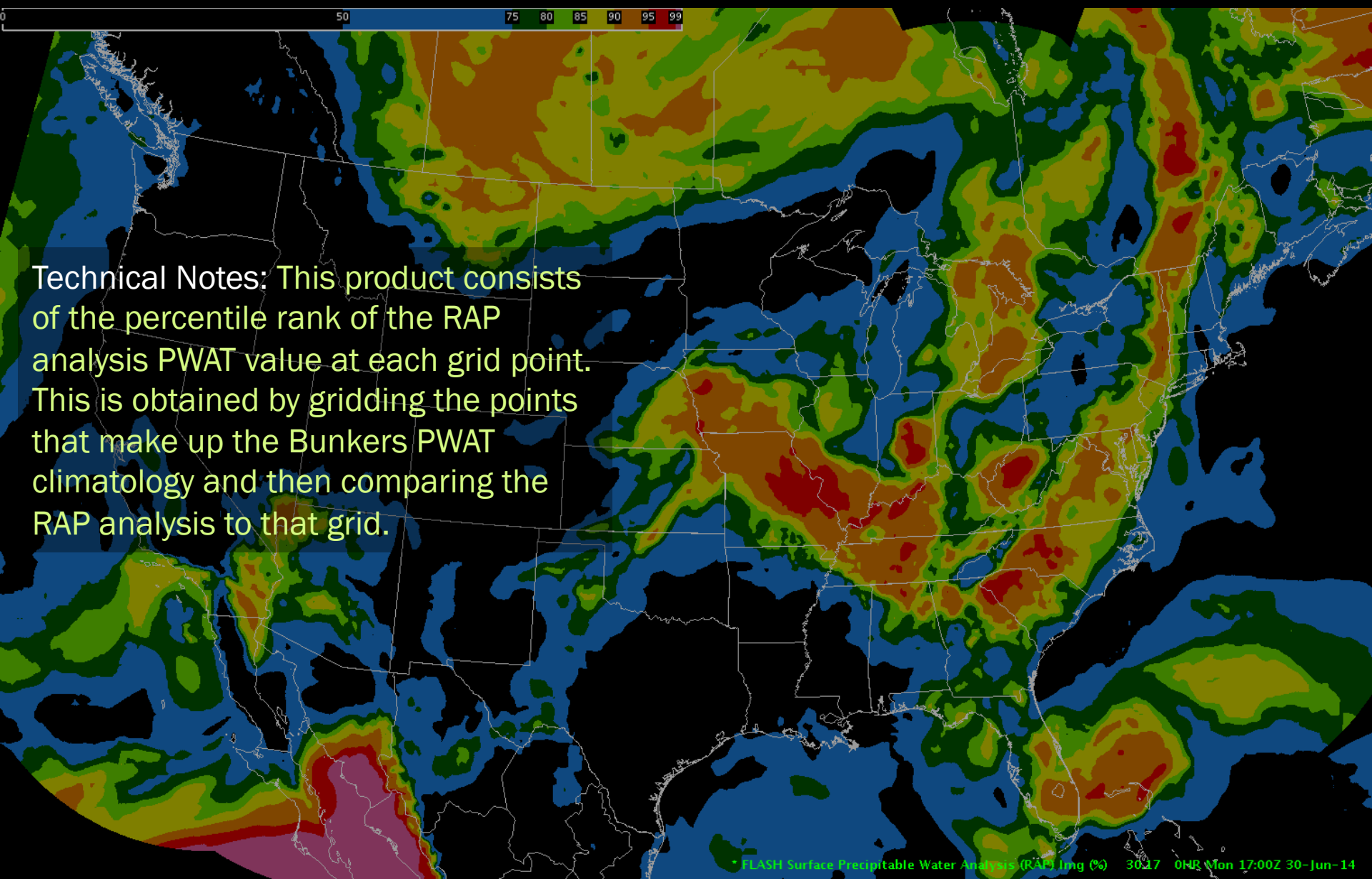
Availability: Hourly; should appear in  
CAVE ~1 hr after valid time

Input: RAOBs, integrated retrievals  
from GPS (see  
[rapidrefresh.noaa.gov](http://rapidrefresh.noaa.gov)), PWAT  
climatology

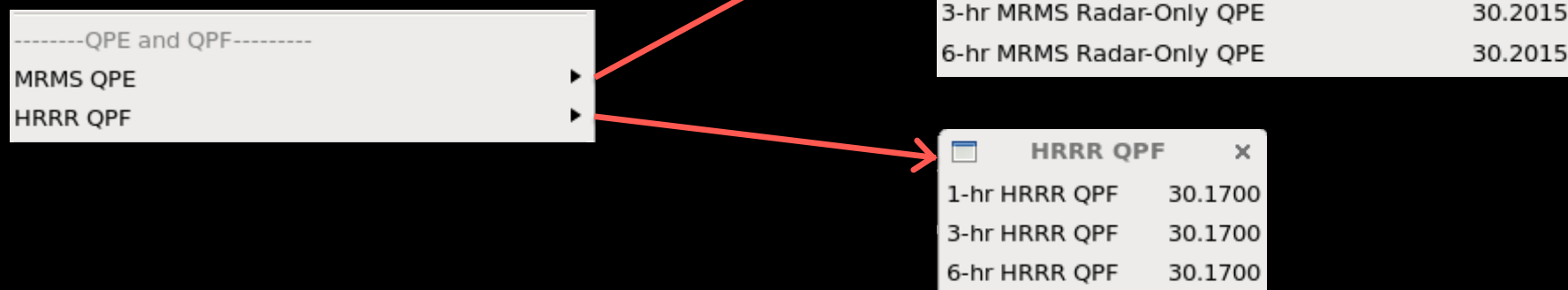
Usage: Values in the 90<sup>th</sup> percentile  
or higher suggest heavy  
rainfall is possible. Values in  
the 99<sup>th</sup> percentile have been  
associated with major flash  
flooding events.

Colors: black = 0 – 50%  
blue = 50 – 75%  
green = 75 – 80%  
yellow = 85 – 90%  
orange = 90 – 95%  
red = 95 – 99%  
pink = 99 – 100%

# Precipitable Water Percentile (RAP)

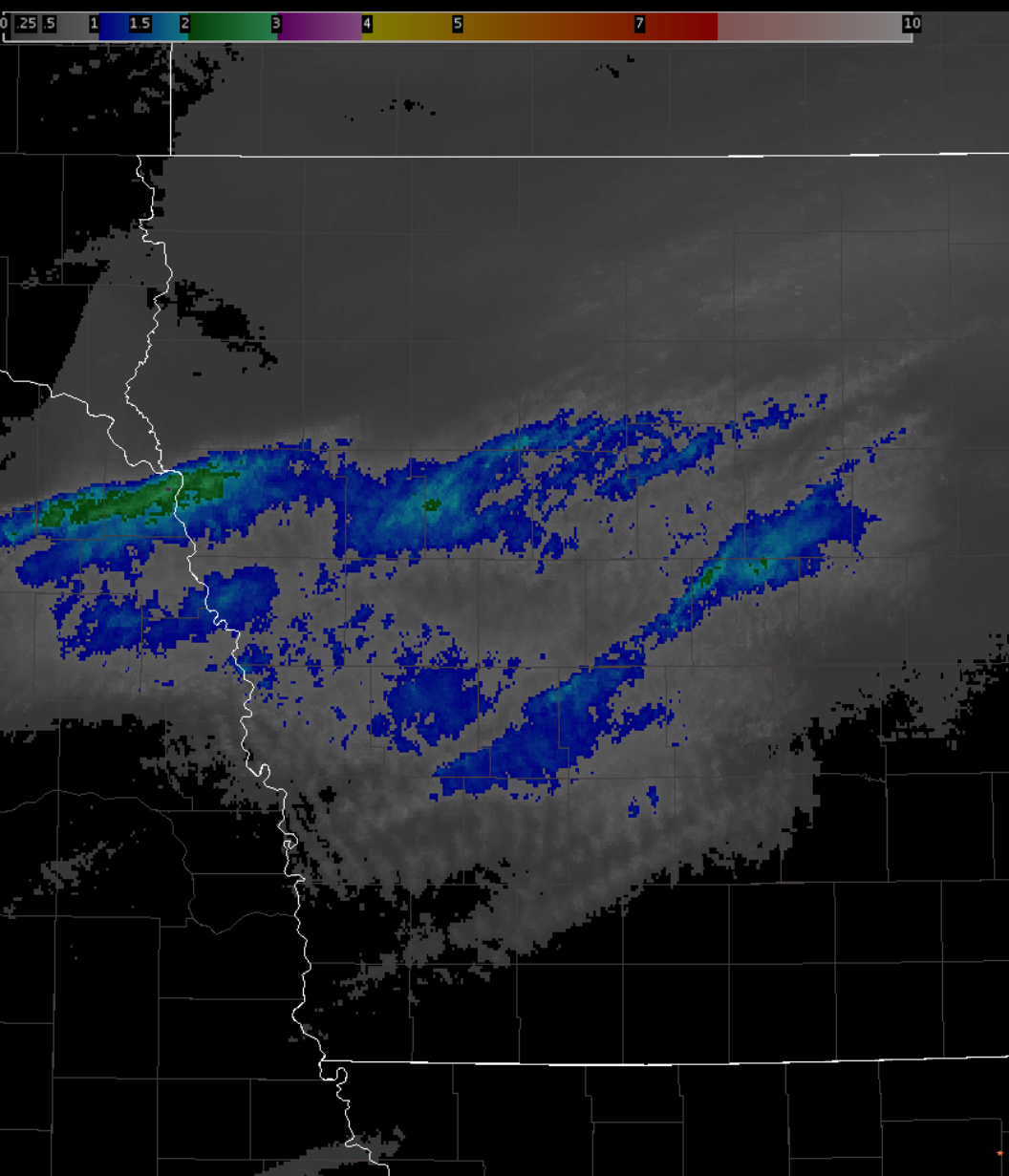
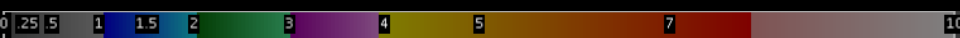


# QPE and QPF



- 7 total products
- QPE from the Multi-Radar/Multi-Sensor project
- QPF from the High Resolution Rapid Refresh model

# 1-, 3-, 6-hr MRMS Radar-Only QPE



Output: 1-, 3-, or 6-hr radar-derived QPE

Scale: 0.0 – 10.0 in

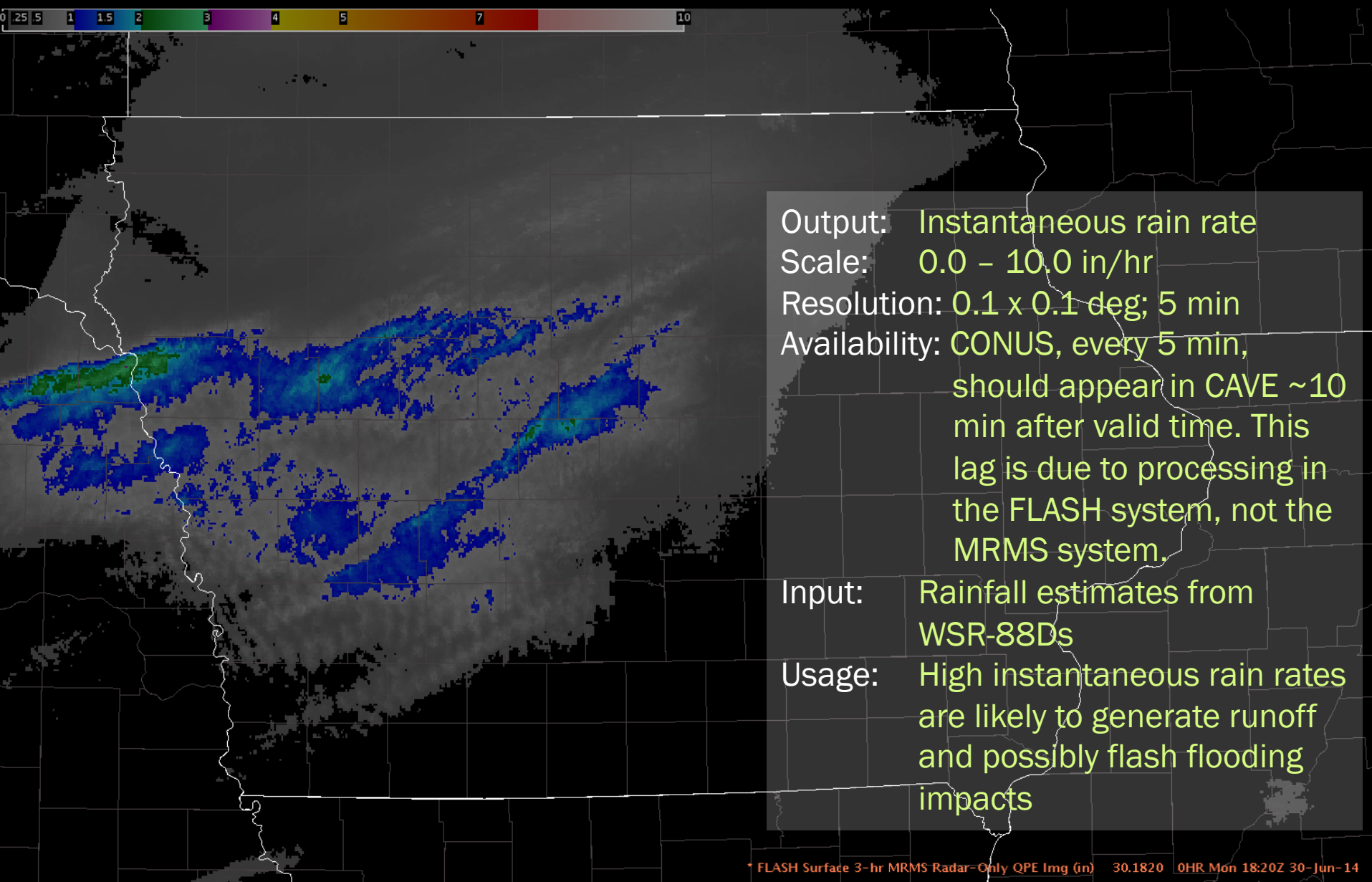
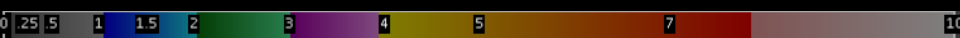
Resolution: 0.1 x 0.1 deg; 5 min

Availability: CONUS, every 5 min, should appear in CAVE ~10 min after valid time. This lag is due to processing in the FLASH system, not the MRMS system.

Input: Rainfall estimates from WSR-88Ds

Usage: Rainfall accumulations can be used to identify areas experiencing heavy rainfall and thus at risk for flash flooding impacts

# MRMS Radar-Only Instantaneous Rain Rate



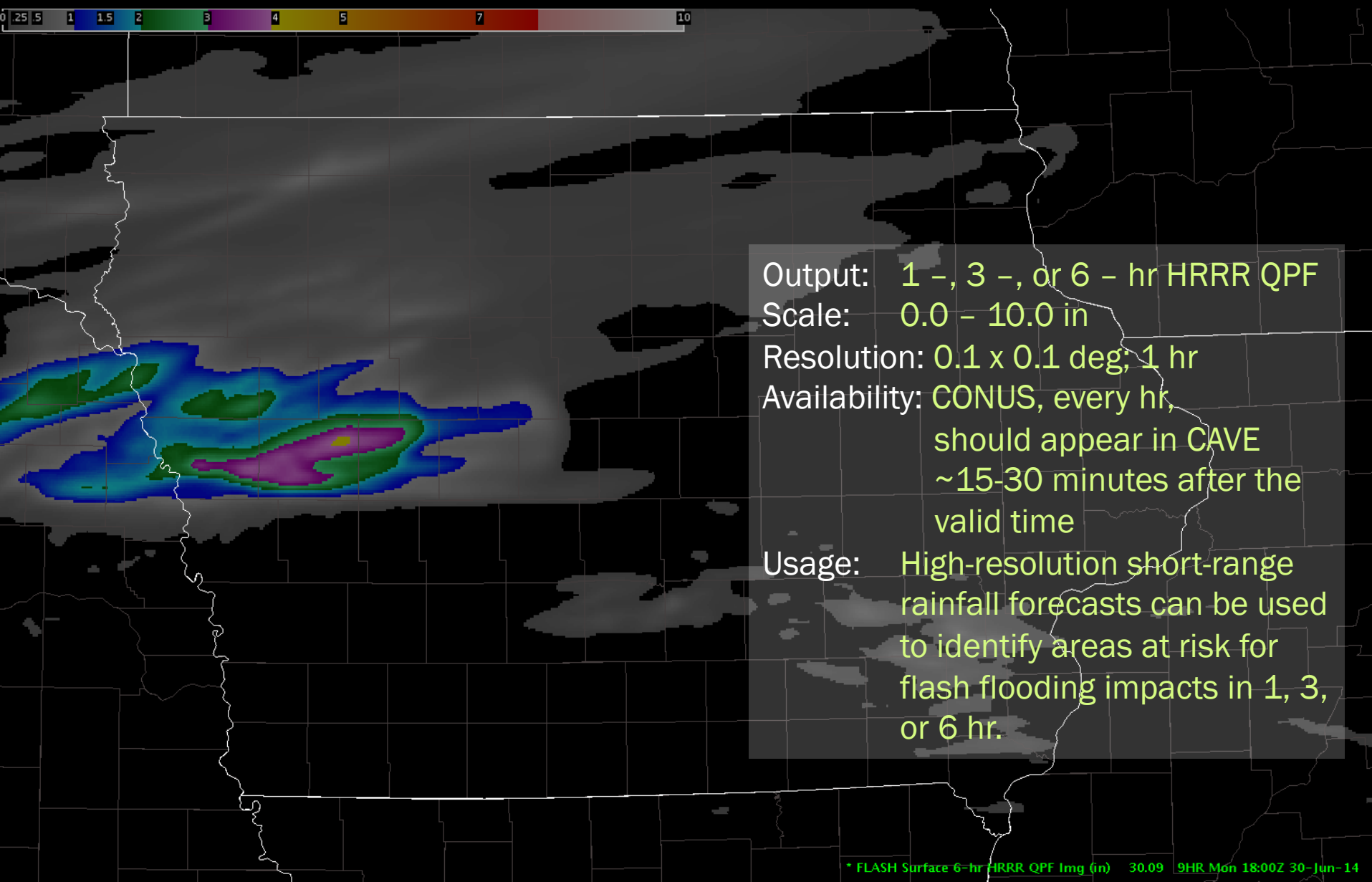
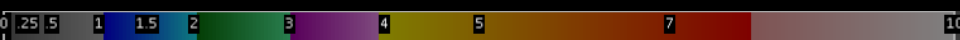
Output: Instantaneous rain rate  
Scale: 0.0 – 10.0 in/hr  
Resolution: 0.1 x 0.1 deg; 5 min  
Availability: CONUS, every 5 min, should appear in CAVE ~10 min after valid time. This lag is due to processing in the FLASH system, not the MRMS system.

Input: Rainfall estimates from WSR-88Ds

Usage: High instantaneous rain rates are likely to generate runoff and possibly flash flooding impacts



# 1-, 3-, 6-hr HRRR QPF



Output: 1 -, 3 -, or 6 - hr HRRR QPF

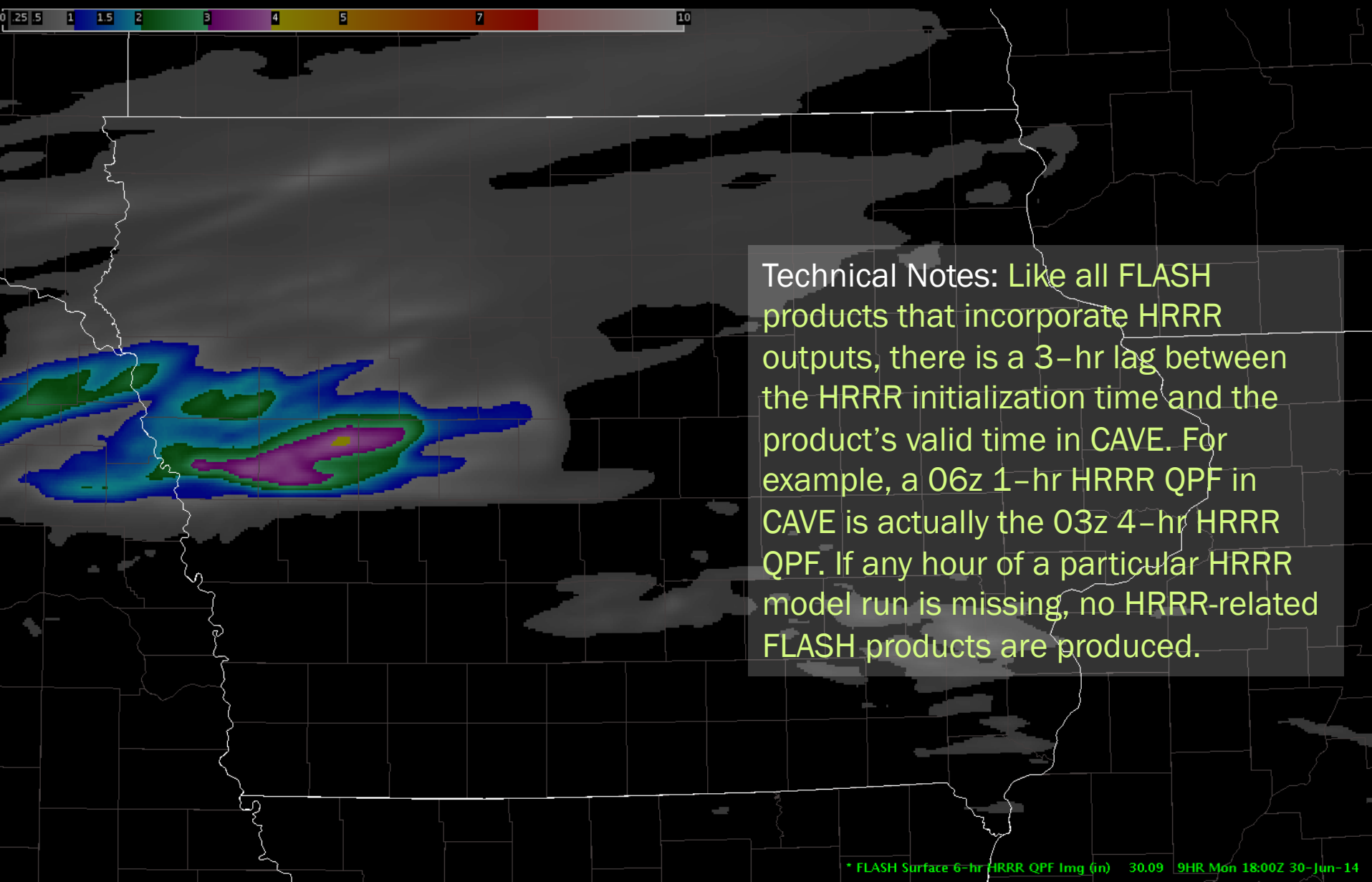
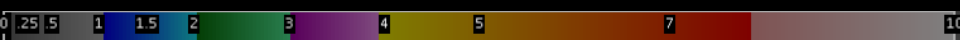
Scale: 0.0 - 10.0 in

Resolution: 0.1 x 0.1 deg; 1 hr

Availability: CONUS, every hr,  
should appear in CAVE  
~15-30 minutes after the  
valid time

Usage: High-resolution short-range  
rainfall forecasts can be used  
to identify areas at risk for  
flash flooding impacts in 1, 3,  
or 6 hr.

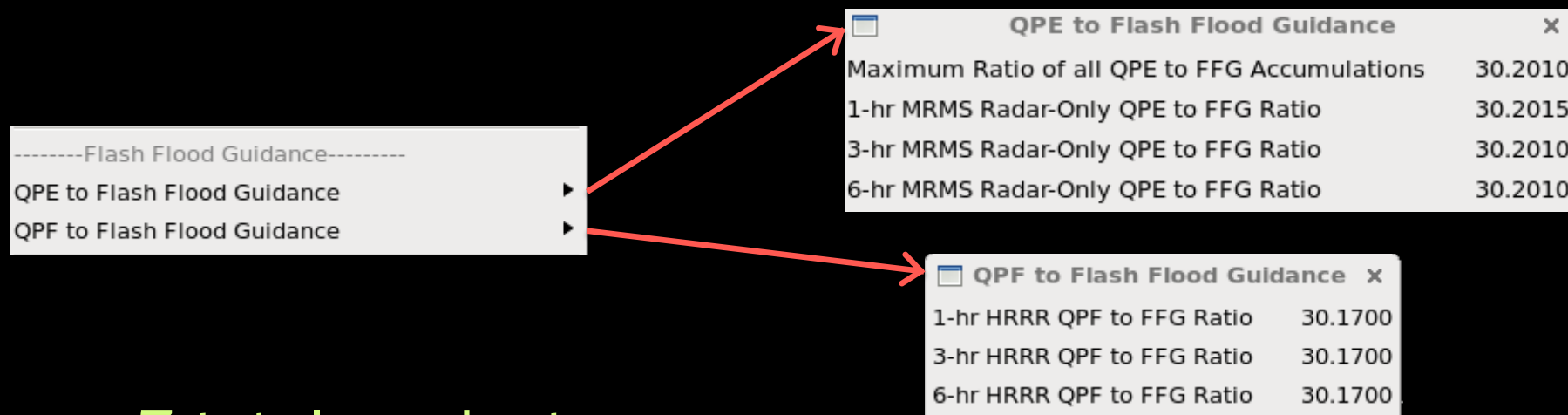
# 1-, 3-, 6-hr HRRR QPF



Technical Notes: Like all FLASH products that incorporate HRRR outputs, there is a 3-hr lag between the HRRR initialization time and the product's valid time in CAVE. For example, a 06z 1-hr HRRR QPF in CAVE is actually the 03z 4-hr HRRR QPF. If any hour of a particular HRRR model run is missing, no HRRR-related FLASH products are produced.

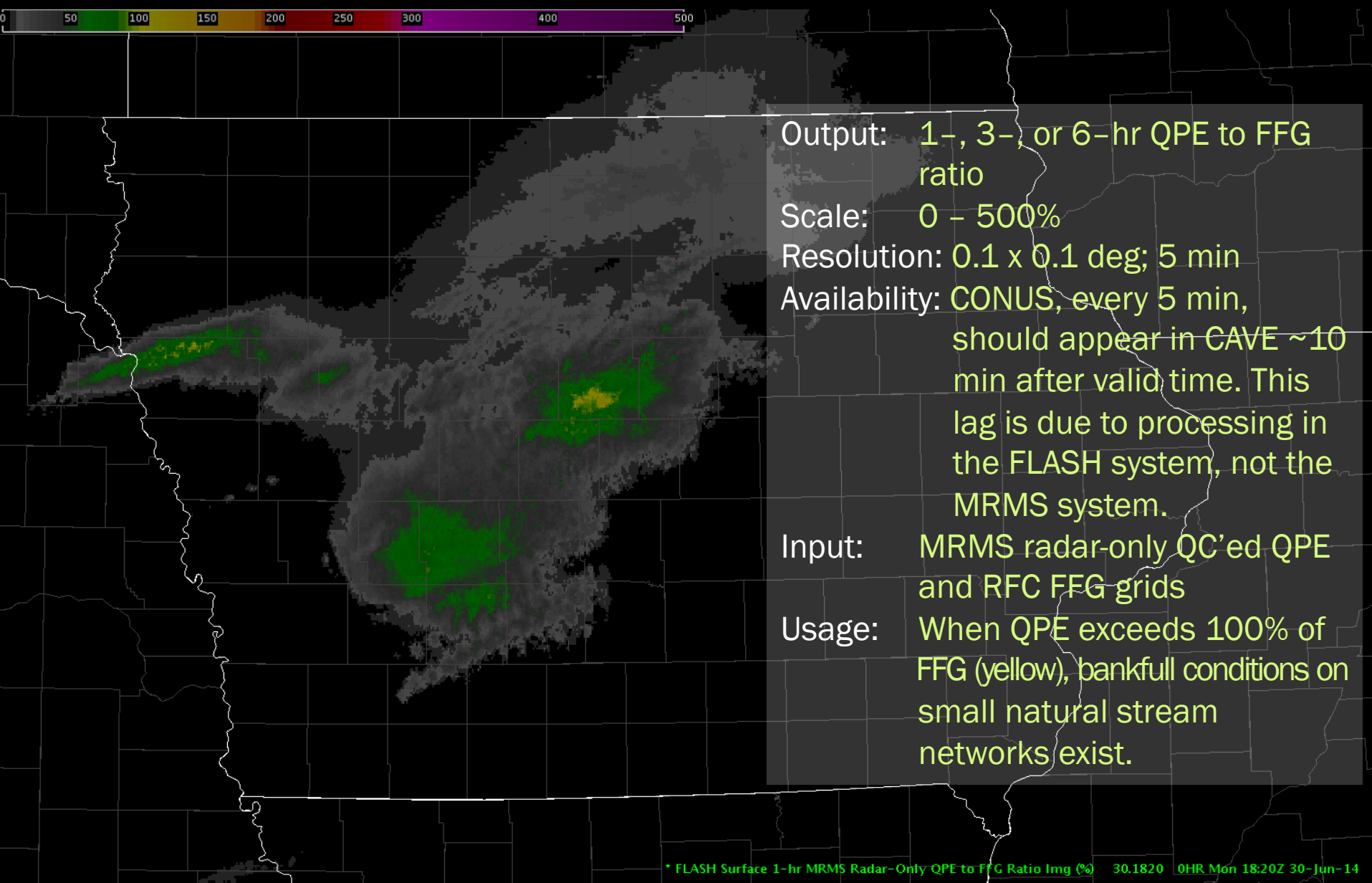


# Flash Flood Guidance



- 7 total products
- QPE from the Multi-Radar/Multi-Sensor project
- QPF from the High Resolution Rapid Refresh model
- FFG is mosaicked from individual RFC grids at NCEP WPC and sent to FLASH system

# 1-, 3-, 6-hr MRMS Radar-Only QPE to FFG Ratio



Output: 1-, 3-, or 6-hr QPE to FFG ratio

Scale: 0 – 500%

Resolution: 0.1 x 0.1 deg; 5 min

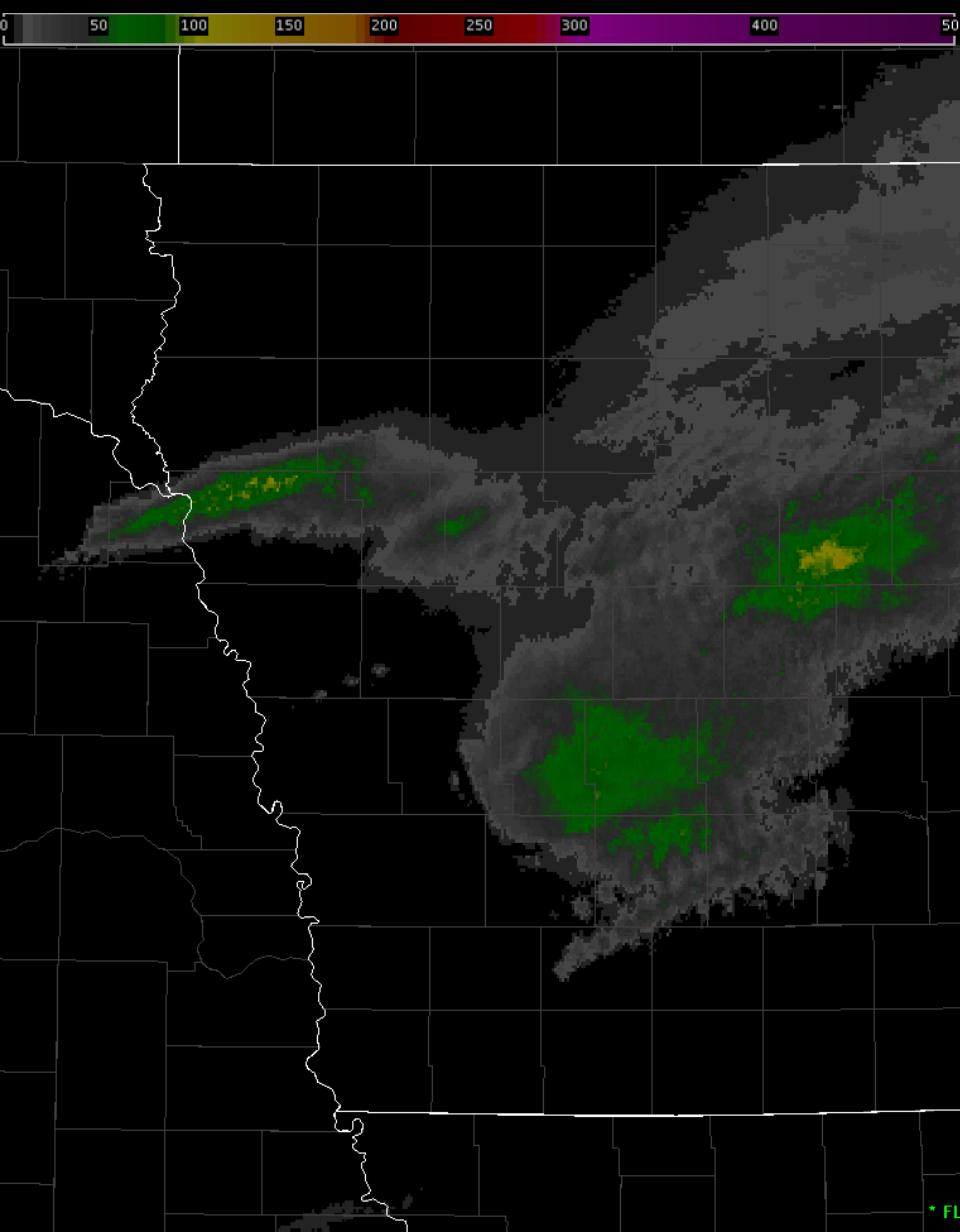
Availability: CONUS, every 5 min, should appear in CAVE ~10 min after valid time. This lag is due to processing in the FLASH system, not the MRMS system.

Input: MRMS radar-only QC'ed QPE and RFC FFG grids

Usage: When QPE exceeds 100% of FFG (yellow), bankfull conditions on small natural stream networks exist.

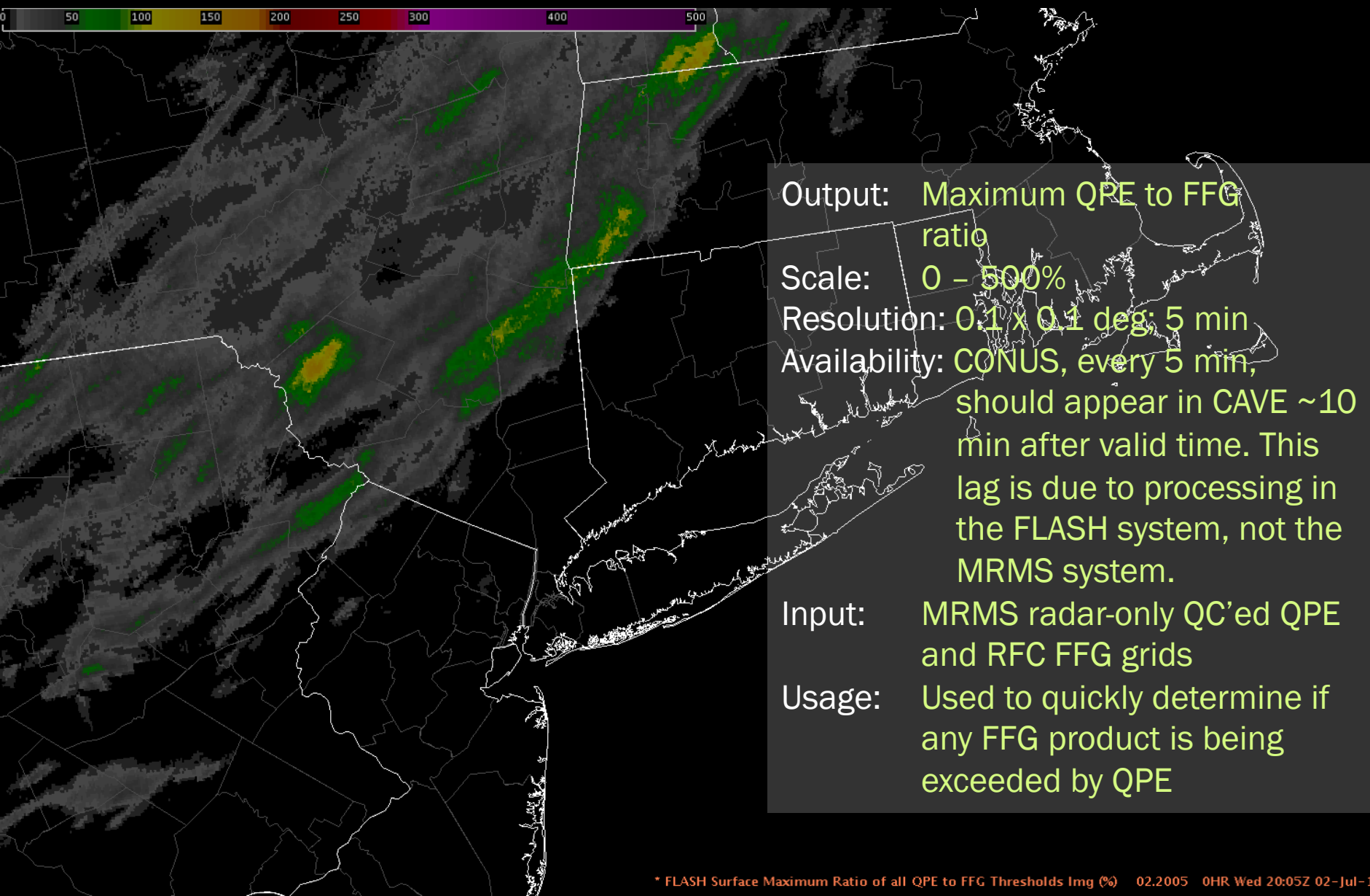
# 1-, 3-, 6-hr MRMS Radar-Only QPE to FFG Ratio

0 50 100 150 200 250 300 400 500

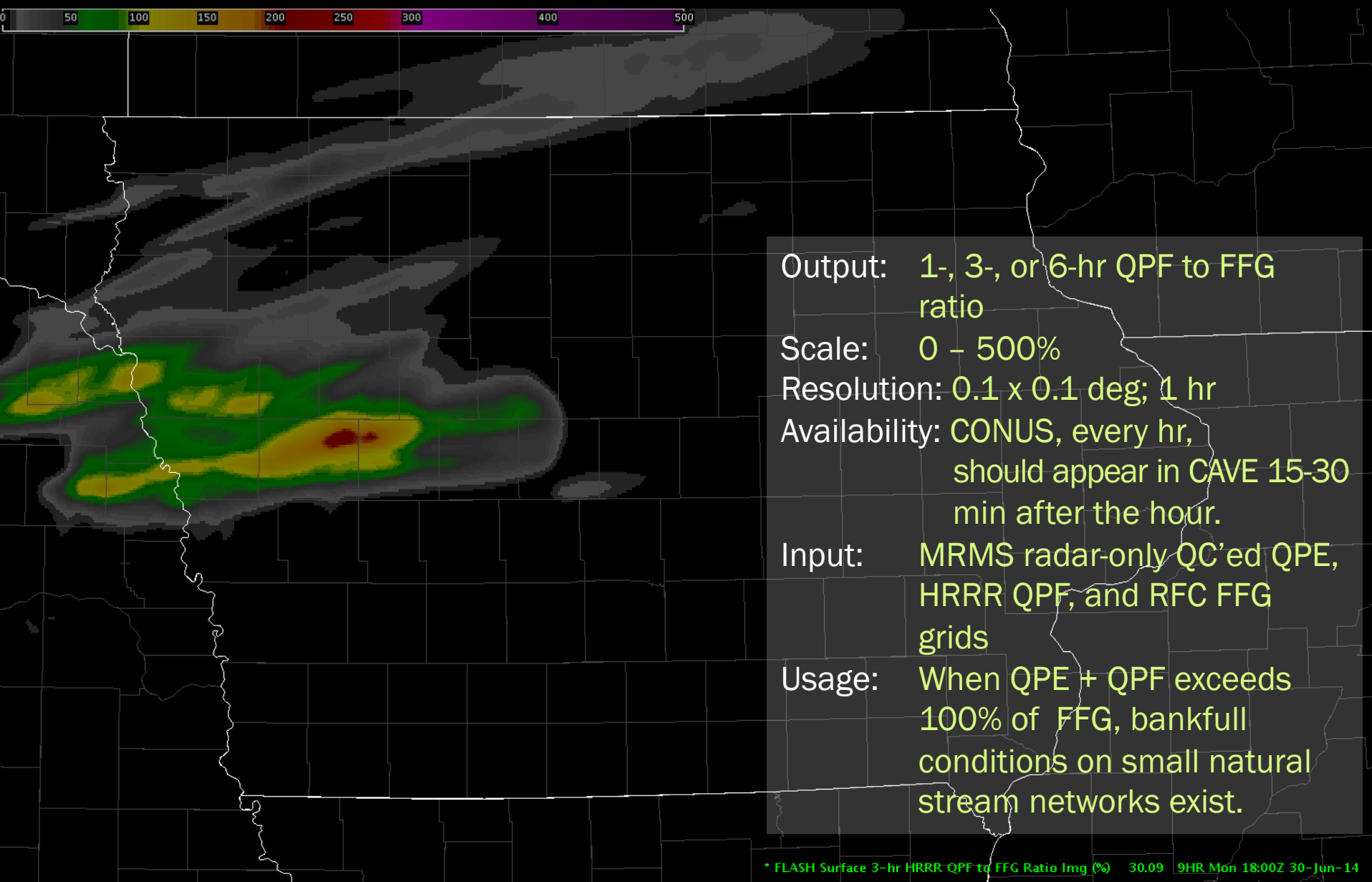


Technical Notes: Flash Flood Guidance is produced at 12 River Forecast Centers between 1 and 4 times per day. Here, it appears in 1-, 3-, and 6-hr flavors. FFG is defined as the amount of rainfall required in that time to cause bankfull conditions on small natural stream networks. FFG is produced differently from RFC to RFC, so use caution in interpreting the product along these domain boundaries. Unlike FFMP, we cannot “zero out” antecedent precipitation when an FFG grid is updated. Therefore, be aware that spuriously high ratios may appear immediately after a new FFG grid is ingested.

# Maximum QPE to FFG Ratio of All Accumulations



# 1-, 3-, 6-hr HRRR QPF to FFG Ratio

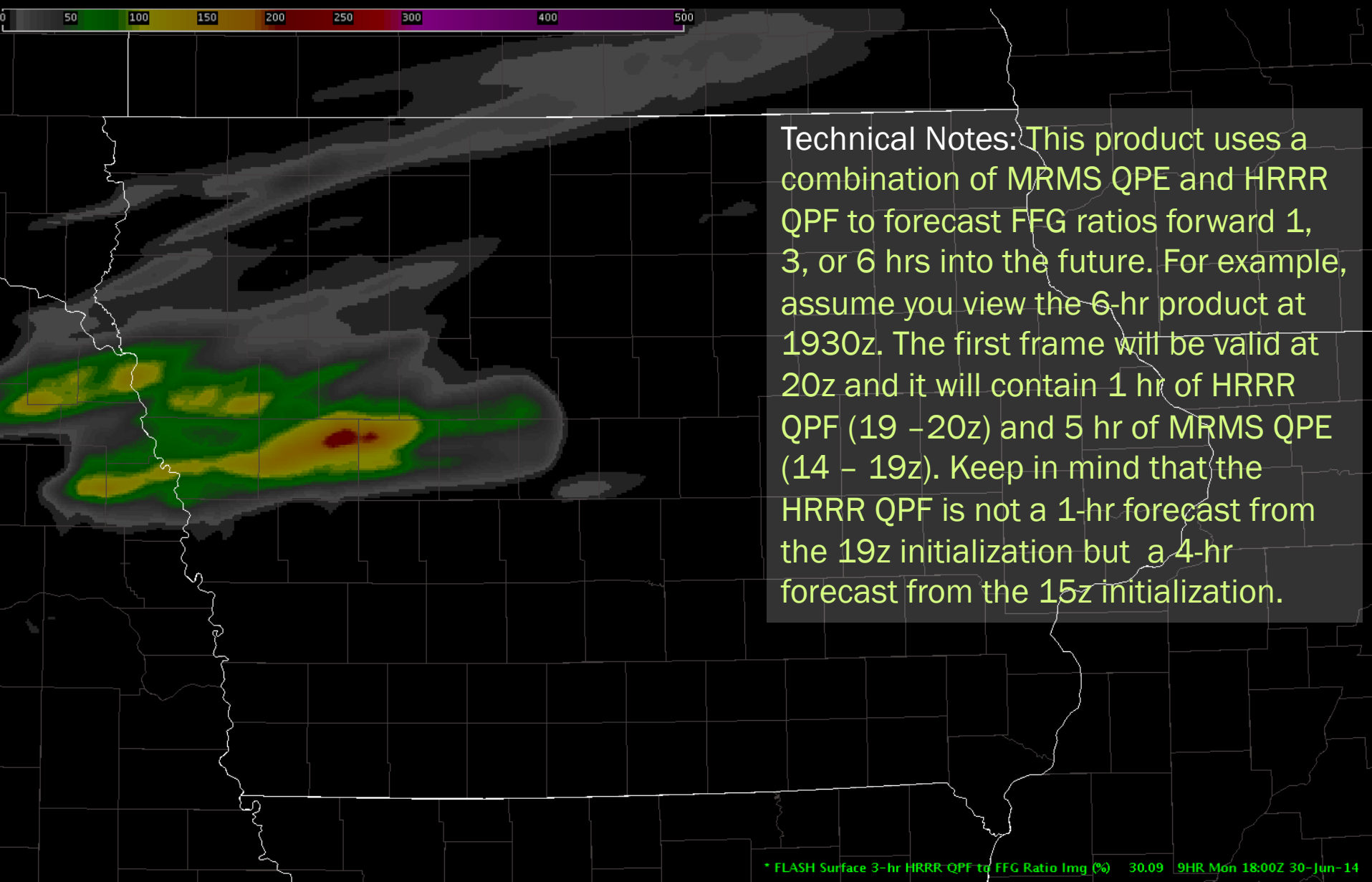


Output: 1-, 3-, or 6-hr QPF to FFG ratio  
Scale: 0 – 500%  
Resolution: 0.1 x 0.1 deg; 1 hr  
Availability: CONUS, every hr, should appear in CAVE 15-30 min after the hour.  
Input: MRMS radar-only QC'ed QPE, HRRR QPF, and RFC FFG grids  
Usage: When QPE + QPF exceeds 100% of FFG, bankfull conditions on small natural stream networks exist.



# 1-, 3-, 6-hr HRRR QPF to FFG Ratio

0 50 100 150 200 250 300 400 500



# Precipitation Return Periods

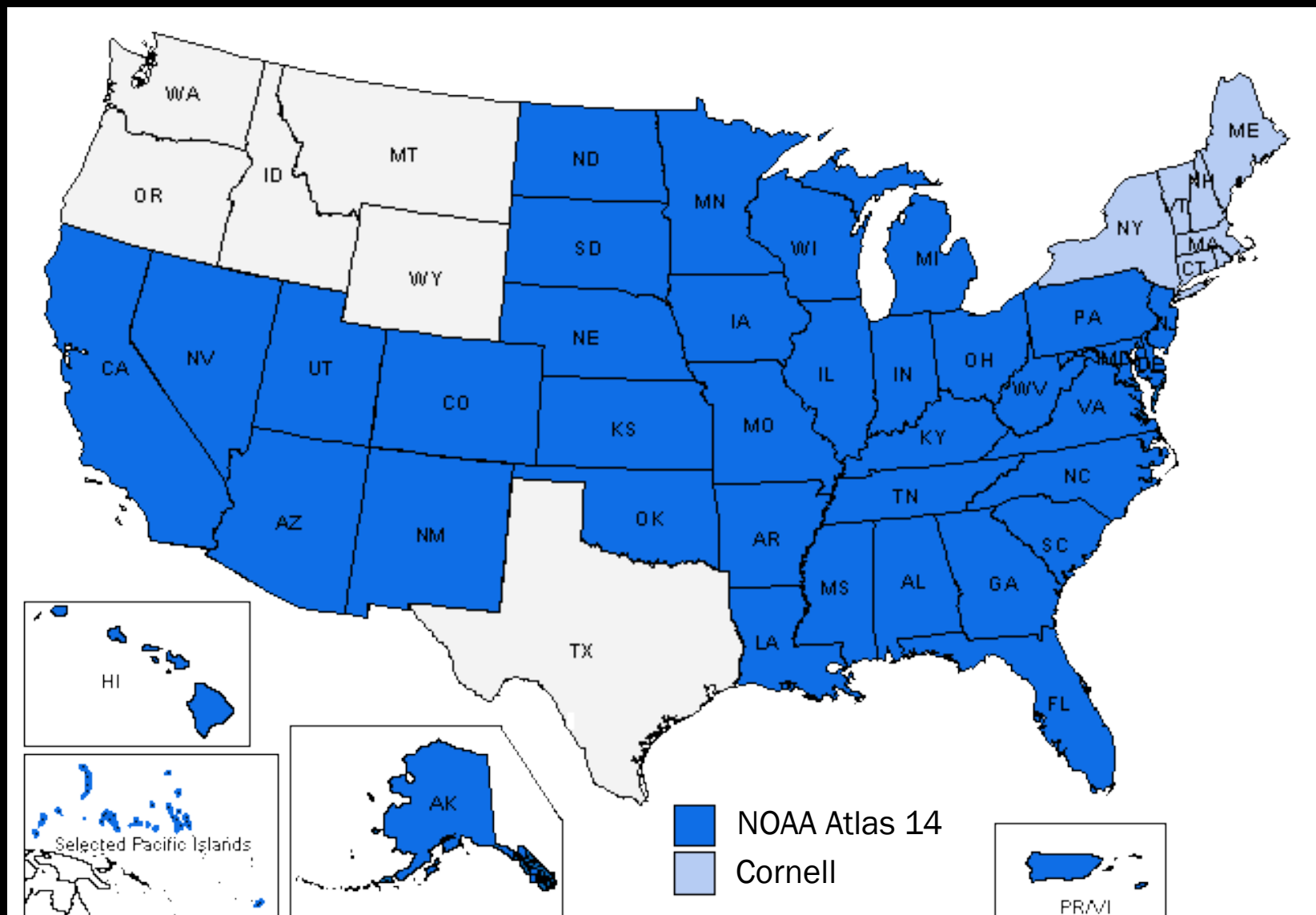
-----Precipitation Return Periods-----	
Precipitation Return Periods (QPE)	▶
Precipitation Return Periods (QPF)	▶

Precipitation Return Periods (QPE)		x
Maximum Precipitation Return Period of all Accumulations		--.----
1-hr Precipitation Return Period		30.2015
3-hr Precipitation Return Period		30.2015
6-hr Precipitation Return Period		30.2010
12-hr Precipitation Return Period		30.2010
24-hr Precipitation Return Period		29.2350

Precipitation Return Periods (QPF)		x
1-hr Precipitation Return Period (Forecast)		30.1700
3-hr Precipitation Return Period (Forecast)		30.1700
6-hr Precipitation Return Period (Forecast)		30.1700

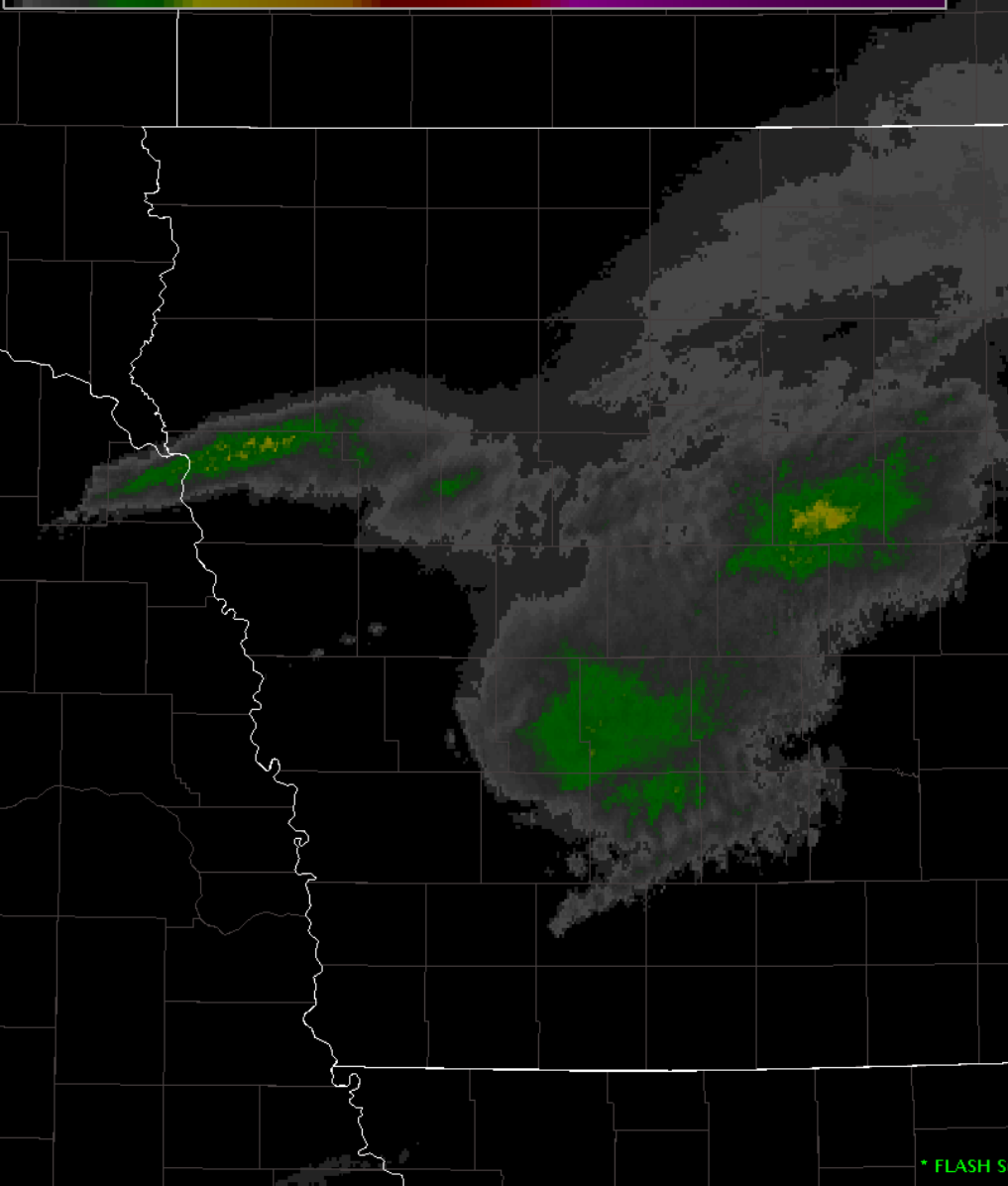
- 9 total products
- QPE from the Multi-Radar/Multi-Sensor project
- QPF from the High Resolution Rapid Refresh model
- Precipitation is compared to NOAA Atlas 14 or the Cornell NY/NE Extreme Precipitation dataset

# Precipitation Return Periods



# 1-, 3-, 6-, 12-, and 24-hr Precipitation Return Period

0 50 100 150 200 250 300 400 500



Output: 1-, 3-, 6-, 12-, or 24-hr precipitation return period

Scale: 0 – 500 yrs

Resolution: 0.1 x 0.1 deg; 5 min

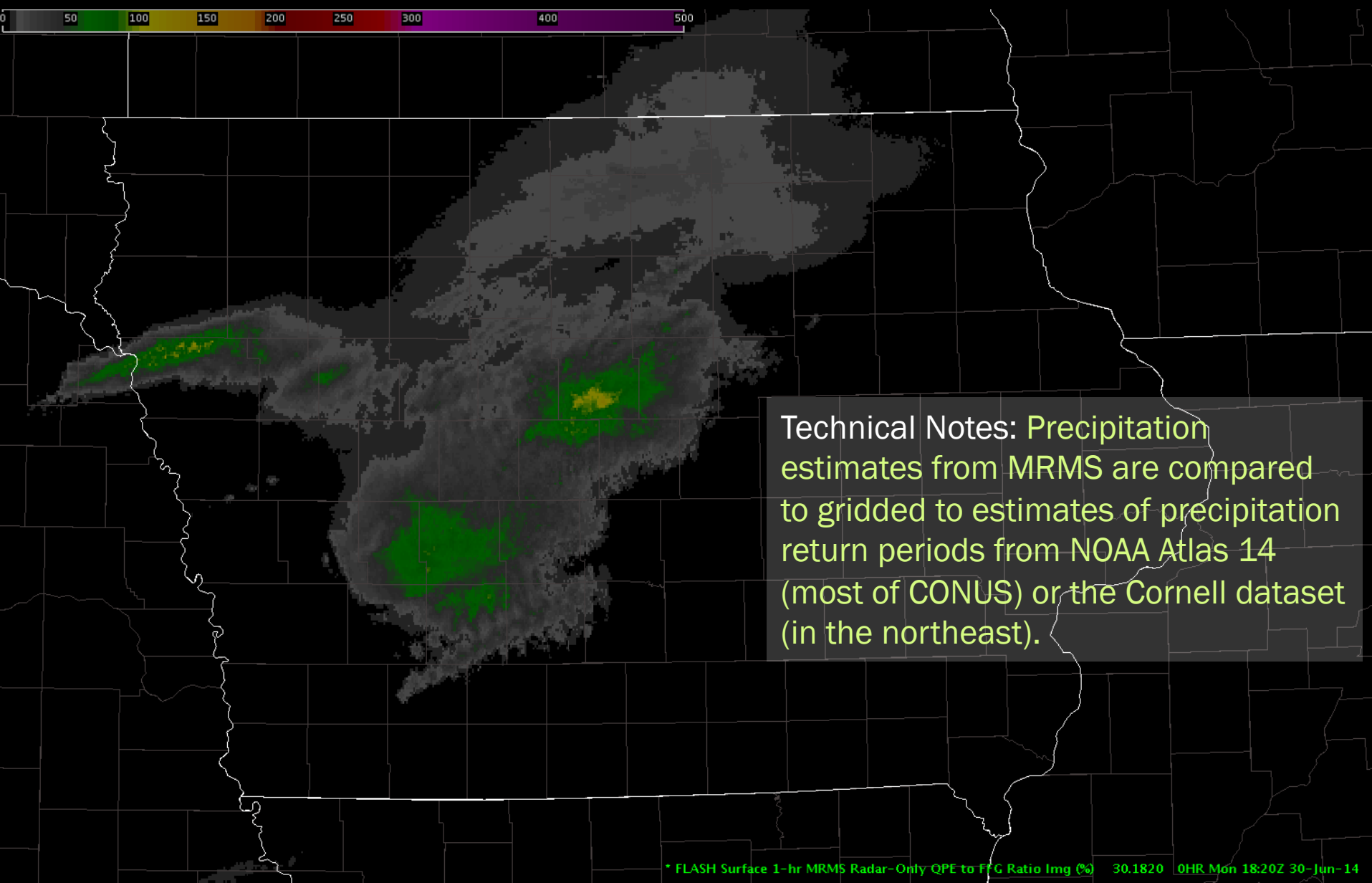
Availability: CONUS except TX, ID, MT, WY, WA, and OR; every 5 min; should appear in CAVE ~10 min after valid time. This lag is due to processing in the FLASH system, not the MRMS system.

Input: MRMS radar-only QC'd QPE, NOAA Atlas 14 Precipitation Return Periods, and Cornell New York & New England Extreme Precipitation dataset

Usage: Extreme precipitation return periods are likely to overwhelm small streams and infrastructure

# 1-, 3-, 6-, 12-, and 24-hr Precipitation Return Period

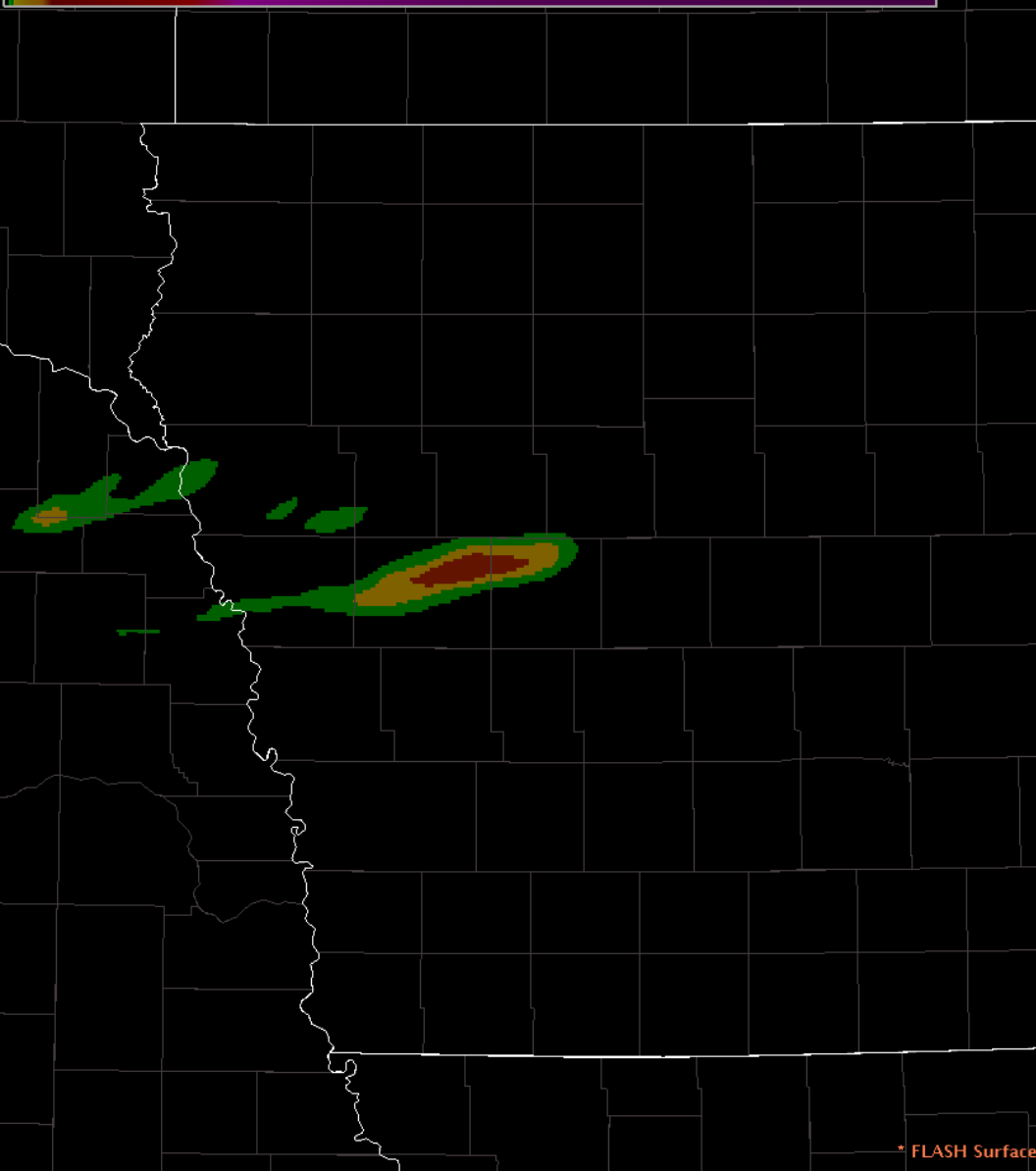
0 50 100 150 200 250 300 400 500



Technical Notes: Precipitation estimates from MRMS are compared to gridded estimates of precipitation return periods from NOAA Atlas 14 (most of CONUS) or the Cornell dataset (in the northeast).



# 1-, 3-, and 6-hr Precipitation Return Period (Forecast)



Output: 1-, 3-, or 6-hr forecast precipitation return period

Scale: 0 – 500 yrs

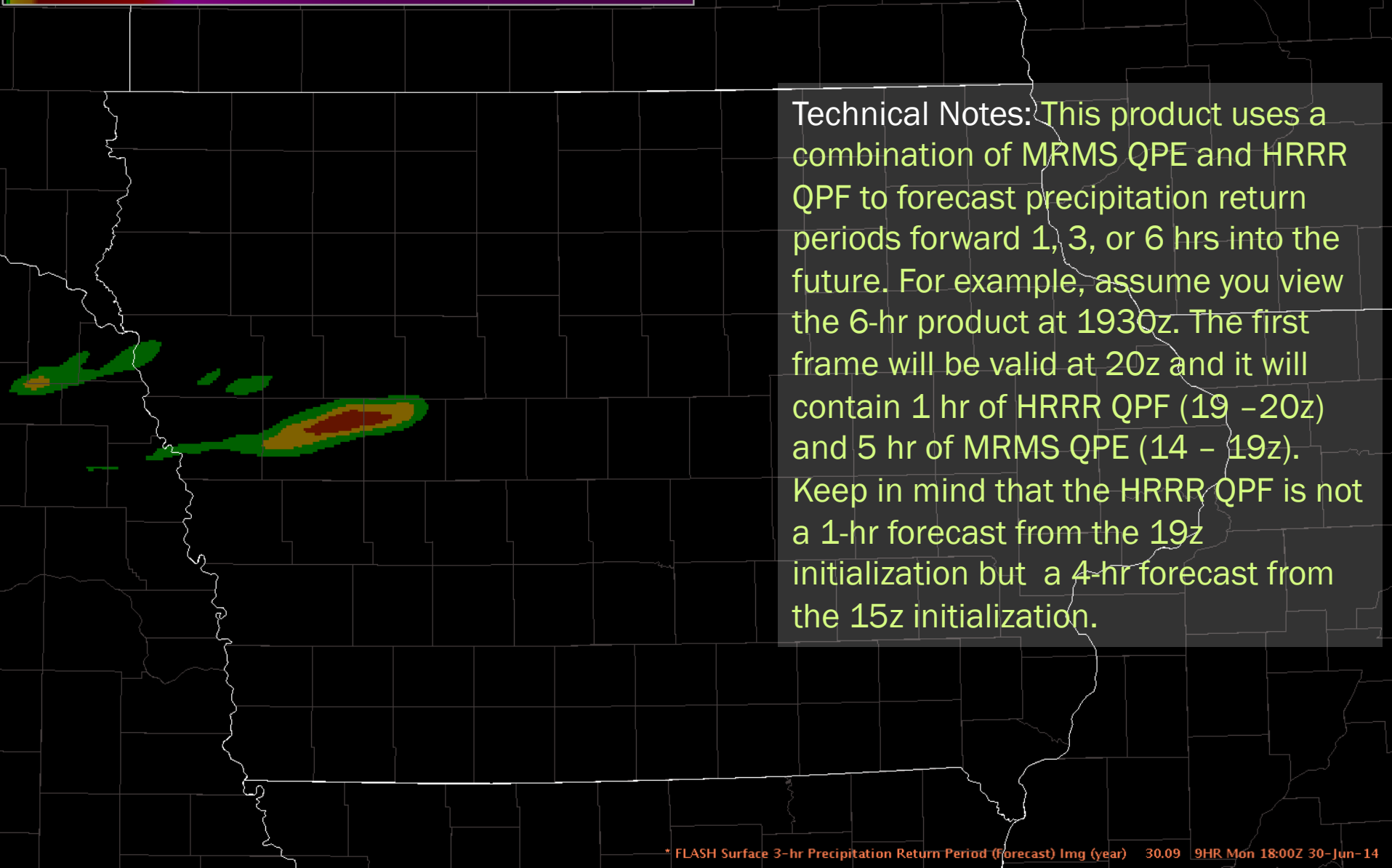
Resolution: 0.1 x 0.1 deg; 1 hr

Availability: CONUS except TX, ID, MT, WY, WA, and OR; every hr; should appear in CAVE 15-30 min after the hour.

Input: MRMS radar-only QC'ed QPE, NOAA Atlas 14 Precipitation Return Periods, Cornell New York & New England Extreme Precipitation dataset, and HRRR QPF

Usage: Extreme precipitation return periods are likely to overwhelm small streams and infrastructure

# 1-, 3-, and 6-hr Precipitation Return Period (Forecast)



Technical Notes: This product uses a combination of MRMS QPE and HRRR QPF to forecast precipitation return periods forward 1, 3, or 6 hrs into the future. For example, assume you view the 6-hr product at 1930z. The first frame will be valid at 20z and it will contain 1 hr of HRRR QPF (19 - 20z) and 5 hr of MRMS QPE (14 - 19z). Keep in mind that the HRRR QPF is not a 1-hr forecast from the 19z initialization but a 4-hr forecast from the 15z initialization.

# Maximum Precipitation Return Period of All Accumulations

Output:	1-, 3-, 6-, 12-, or 24-hr precipitation return period
Scale:	0 – 500 yrs
Resolution:	0.1 x 0.1 deg; 5 min
Availability:	CONUS except TX, the NW, New England, and NY; every 5 min; should appear in CAVE ~10 min after valid time. This lag is due to processing in the FLASH system, not the MRMS system.
Input:	MRMS radar-only QC'ed QPE, NOAA Atlas 14 Precipitation Return Periods, and Cornell New York & New England Extreme Precipitation dataset
Usage:	Used to quickly diagnose the highest precipitation return period regardless of accumulation time period